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ABSTRACT

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Running Head: TASTE PERCEPTION AMONG OVERWEIGHT AND NORMAL WEIGHT WOMEN

Taste Perception: An Examination of Fat Preference, Sensory Specific Satiety, and the Function of Eating Among Overweight and Normal Weight Women

by

Kimberly L. Kalupa

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This work is dedicated to Sarah K. Smith. Although her tragic and untimely death made it impossible for us to meet, she was instrumental to the early development of this study. In many ways this thesis belongs to both of us.

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Overweight and obesity form the basis of the second leading cause of preventable death in the United States and are on the rise (NIH, 1998). Prevalence of overweight, defined as a body mass index (BMI) between 25-29.9 kg/m^2, in men and women increased from 30.5 to 32% between 1960 and 1994 (NIH, 1998). Even more dramatic, is the increased prevalence of obesity (BMI >30 kg/m^2), from 12.8 to 22.5%, during that same time frame (NIH, 1998). Fortunately, many of the risks associated with overweight and obesity can be reduced if small to moderate (10%) weight loss is achieved (NIH, 1998).

Over the past two to three decades, behavioral programs have been successful in promoting clinically significant weight losses. Unfortunately, the maintenance of these losses are rather dismal, with more than 30-40% of lost weight being regained within one year for men and women who underwent behavioral treatment of obesity (Perri, 1998). Two to five-year follow-up of behavioral treatments for obesity indicate a gradual, but nearly certain return to baseline weights (Kramer, Jeffery, Forster, & Snell, 1989; Stalonas, Perri, & Kerzner, 1984; Wadden, Sternberg, Letizia, Stunkard, & Foster, 1989). In a recent review of the efficacy of techniques added to improve maintenance of losses achieved by traditional behavior therapy, Perri (1998) concluded that weight regain was evident upon program termination. One exception to this is the Behavioral Choice Treatment (BCT) proposed by Sbrocco and colleagues (Sbrocco, Nedegaard, Stone, & Lewis, 1999). Unlike traditional behavior therapy approaches to weight loss, BCT promoted continued weight loss even at a two year follow up (Sbrocco et al., 1999). This approach emphasizes the need to understand factors controlling eating behavior. Given the prevalence of the problem of obesity and the paucity of successful long-term

treatments, there is still much to be learned about eating behavior in obesity. More specifically, there is a need to further examine potential mechanisms that may differentiate obese from normal weight individuals. These potential mechanisms include differences in eating patterns, metabolic changes associated with food intake, and taste and related factors.

In the U.S., lifestyle factors have contributed significantly to the development of obesity. Advances in technology have encouraged many Americans to adopt sedentary lifestyles, in the context of an environment where high fat, highly palatable foods are readily available. Dissuading individuals from choosing such foods is very difficult. Clearly the choice of what to eat is multiply determined in humans. Choices ultimately depend on some complex combination of hedonic factors, cognitive factors, sensory factors, physiological needs, powerful instinctive tendencies, and acquired habits (Young, 1977). Some food preferences, like preference for sweet tastes, are innate, whereas preference for other flavors develop as a function of repeated exposure and experience (Hetherington & Rolls, 1996). From an evolutionary perspective, the taste-related factors that developed to direct humans to consume safe foods and to obtain sufficient energy now may contribute to the problem of overweight. Sensitivity to sweet tastes may have developed to help humans identify high-energy (carbohydrate based) foods (Young, 1977). Sensitivities and preferences also may have developed for tastes other than sweet to enhance survival. Given the relative caloric density of fat compared to carbohydrates, sensitivity to fat might have even greater evolutionary value for survival. This “caloric advantage” has been hypothesized to contribute to a fat preference (Schiffman, Graham, Sattely-Miller, & Warwick, 1998)

Currently, little is known about possible differences in taste perception and taste preferences between overweight and normal weight individuals (Jeffery et al., 2000; Kumanyika et al., 2000). Taste related parameters are particularly important for treating obesity because weight reduction programs may significantly impact taste through their impact on food intake. Traditionally, weight loss programs recommend dietary modification through caloric restriction and modification of macronutrient composition. Low fat diets have been heralded as a means for individuals to lose and maintain body weight without "depriving" themselves. This approach capitalizes on the thermic effect of food and the differences in energy density of fat versus carbohydrate. However, reducing dietary fat can significantly alter a diet's palatability. Given that maintenance of weight loss remains the exception, the relationship of palatability to dietary adherence warrants further examination. Several questions regarding the reinforcement value of food and the role of palatability in the etiology and maintenance of obesity remain and the need to further examine the potential role of taste-related mechanisms in the development of obesity has recently been highlighted (Jeffery et al., 2000; Kumanyika et al., 2000).

Differentiating obese and normal weights

Many of the taste-related mechanisms generally thought to underlie eating behavior have been studied separately in normal weight or obese populations. Surprisingly, little attention has been given to the role of fat perception and fat preference in the development and maintenance of obesity. Research to date has largely been to the limited impact of sweet tastes on preference for foods and consumption of foods.

There is, however, an extensive literature examining potential psychological characteristics that may differentiate obese and normal weights.

Schachter's Theory of Externality

Schachter's Theory of Externality (1971) was one of the first comprehensive and testable explanations proposed to differentiate the eating behavior of obese and normal weight individuals. Schachter (1971) proposed that obese individuals are more sensitive and reactive to stimuli and that they are relatively insensitive to internal cues, such as hunger. In other words, normal weight individuals eat in response to hunger (an internal cue), whereas obese individuals are more likely to eat after seeing or smelling foods (external cues), even if they are not hungry. Research on this theory has revealed some interesting differences between normal weight and overweight individuals in their responses to external and internal cues. For example, overweight individuals ate more when they perceived it to be dinnertime (Schachter, 1971), when the food was highly palatable (Schachter & Rodin, 1974), and when given a solid preload prior to a meal (Schachter, 1971). In contrast, Schachter and Rodin (1974) found that overweight individuals ate less than normal weight individuals in the absence of salient sensory cues or when the food tasted bad. In fact, overweight individuals only "out-ate" their normal weight counterparts when they liked the foods that were offered.

Unfortunately, there are some problems with the original Externality theory. The majority of the research on Externality was conducted on college males, most of who would not be considered obese by more recent standards. Consequently, Externality theory has been criticized for having limited generalizability since the population used by

Schachter did not accurately represent the majority of obese and overweight individuals. In addition, Schachter's presentation of internal and external cues as mutually exclusive factors has been criticized as an over-simplification of how these factors influence eating behavior (Drewnowski & Greenwood, 1983). Findings from other studies indicated contradictory results with regard to externality of obese subjects (Rodin, 1981). Externality was not exclusively found in obese subjects and Rodin (1981) reported that externality occurs in individuals of all weight classes and can evoke overeating if the right environment is created. Similarly, sensitivity to internal cues has been found in some obese subjects, leading Rodin (1981) to conclude that the rigid separation of internal and external cues was a premature decision, as research indicates that some external stimuli exert their influence through their impact on internal cues. As a result, research endeavors using Externality theory to distinguish between normal weight and obese subjects were largely abandoned (Drewnowski, 1996).

Despite these criticisms, the research on obesity conducted by Schachter and his colleagues was important to understand eating behavior because they sought to examine differences between obese and normal weight individuals and their work was theory driven. In fact, Externality theory has not been fully tested and still holds some intuitive appeal with regard to potential etiological mechanisms for obesity. The current study seeks to explore some of the same questions raised by Schachter's group, but in more clearly defined groups of obese and normal weight women from a community sample.

Dietary Restraint

After the simple external/internal dichotomy between obese and normal weight

subjects was challenged, the examination of psychological factors that impact eating behavior took a new direction. Following from Schachter's work, Herman and Mack (1975) examined individual differences in eating behavior utilizing the construct of "dietary restraint," a cognitive factor relevant to eating behavior. Initially, dietary restraint was proposed as a means to differentiate dieters from non-dieters, but the definition of a restrained eater changed over time (Drewnowski, Brunzell, Sande, Iverius, & Greenwood, 1985; Ruderman, 1986). Restrained eaters are individuals who are highly restrictive with regard to what they eat most of the time, but then overeat when disinhibited (Ruderman, Belzer, & Halperin, 1985). Several factors have been identified to cause disinhibition in restrained eaters. Some of these factors include the induction of a negative mood state (Cools, Schotte, & McNally, 1992), psychological stress (Ruderman, 1985), and physical threats, such as an anticipated electric shock (Heatherton, Herman, & Polivy, 1991). Therefore, the construct of dietary restraint goes beyond weight status to explain how cognitive factors related to eating, influence eating behavior. Food intake in restrained eaters appears to be moderated more by cognitive factors than physiological factors.

There is a modest literature that examines the impact of taste parameters on the eating behavior of restrained and unrestrained eaters. Dietary restraint, but not weight status, predicted hyper-responsiveness, indexed by rate of salivary flow, to olfactory food cues (LeGoff & Spigelman, 1987). Similarly, double the rate of salivary flow in restrained eaters, relative to unrestrained eaters, was reported when presented with pizza as a stimulus (Tepper, 1992). With regard to specific tastes, Esses and Herman (1984)

reported that after a 12-hour fast, female restrained eaters rated highly concentrated sugar solutions as significantly less pleasant than did unrestrained eaters. After a glucose load, negative alliesthesia to the palatability of sucrose solutions was evident in both restrained and unrestrained eaters (Esses & Herman, 1984). That is, independent of restraint status, the palatability of sugar solutions decreased after the ingestion of a glucose load. In another study without a fasting period, there were no differences in perception of sweetness intensity or preferences between restrained and unrestrained eaters (Frijters, 1984). The differing results could be due to the fact that a forced 12-hour fast may have eliminated the difference in hunger status that may normally exist between restrained and unrestrained eaters. When restrained and unrestrained women were asked to rate the pleasantness, sweetness and fatness of dairy products with differing levels of sugar and fat, differences between the groups were found (Frye, Crystal, Ward, & Kanarek, 1994). Highly restrained eaters preferred less sweet taste stimuli relative to unrestrained eaters (Frye et al., 1994). However, ratings of perceived sweetness or fatness did not differ as a function of restraint status (Frye et al., 1994).

While some interesting differences have been found between individuals of varying levels of dietary restraint, this extension of Schachter's Externality theory fails to explain differences in eating behaviors between normal and overweight individuals *per se*. It does, however, address key differences in eating behavior among chronic dieters and non-dieters, some of whom may be obese.

Taste Parameters: Do obese and normal weights differ?

As noted earlier, there is surprisingly little research on differences in taste

perception among obese and normal weight individuals. Taste perception can be conceptualized as one "external" factor thought to differ between normal weight and overweight individuals. Several aspects of taste have been studied, including taste perception, taste preference, and habituation to particular tastes. Much of this research has been conducted by the food industry and the results remain private property. Individuals working outside of the food industry who have made significant contributions to this area are briefly described below.

Outside of industry research, one of the earliest lines of food consumption research focused on hedonic processes and the development of sweet preferences (Young, 1948a; Young, 1957; Young, 1977; Young & Shuford, 1954). Young conducted some of the earliest research in the area of appetitive behaviors in rats. His work was instrumental in defining and operationalizing critical terms including appetite, preference, palatability, and hedonic responses. In addition, Cabanac was one of the leaders in the search for metabolic differences between obese and normal weight individuals. Cabanac looked for metabolic mechanisms for food intake and satiety (Cabanac & Duclaux, 1970; Cabanac & Rabe, 1976). He believed in the existence of a ponderstat or "weight set point" and examined ways that food palatability interacted with this biological feature.

Other individuals have focused on the effects of sensory and environmental factors on food intake and satiety. One example is Barbara Rolls' work on food palatability and the availability of a variety of tastes on food intake (Rolls, 1990; Rolls, Fedoroff, Guthrie, & Laster, 1990; Rolls, Hetherington, & Burley, 1988; Rolls, Laster, &

Summerfelt, 1991; Rolls, Van Duijvenvoorde, & Rolls, 1984). Much of Rolls' work has immediate clinical utility and applicability. She brought taste-related research out of the laboratory and into the real world. Her work on how the availability of a variety of tastes affects consumption investigated ways of increasing food consumption in the elderly (Rolls, 1999).

For the past two and a half decades, de Castro has examined the impact of physiological, psychological, and sociological factors on eating behavior (de Castro, 1988; de Castro, 1996; de Castro & Brewer, 1992; de Castro, Brewer, Elmore, & Orozco, 1990; de Castro & Kreitzman, 1985). He capitalized on the use of food diaries to investigate the impact of factors that include, but are not limited to, circadian rhythms, hunger, amount of food in stomach, time of the day, day of the week, location, number of people present, and relationship to eating companions on food intake.

In addition, Drewnowski and colleagues have examined the role of sweet and fat perception and preferences on food intake (Drewnowski, ; Drewnowski, 1990; Drewnowski, 1993; Drewnowski et al., 1985; Drewnowski & Greenwood, 1983; Drewnowski, Grinker, & Hirsch, 1982; Drewnowski, Krahn, Demitrack, Nairn, & et al., 1992a; Drewnowski, Kurth, Holden-Wiltse, & Saari, 1992b; Drewnowski & Schwartz, 1990; Drewnowski, Shrager, Lipsky, Stellar, & et al., 1989). The work of Drewnowski and colleagues began to unravel the confusion surrounding earlier taste research by examining more complex relationships including fat and sugar combinations (Drewnowski et al., 1985; Drewnowski & Greenwood, 1983). He also began looking at more detailed individual differences among obese subjects, in order to flesh out

subgroups of obese subjects and to determine the effects of age of onset of obesity and history of weight fluctuation on subsequent food selection (Drewnowski, 1991; Drewnowski, 1993; Drewnowski, Cohen, Faust, & Grinker, 1984).

Overview and Definitions

The subsequent paragraphs briefly review research on taste and taste-related factors relevant to the current investigation on taste preferences in obese and normal weight women. The factors reviewed include taste preference, palatability, hedonic qualities of foods, and sensory specific satiety.

Preference for a taste is more than a simple perceptual difference and, in fact, speaks to an evaluative difference between two or more items that suggests greater palatability of one taste over another (Young, 1977). In human and other animal studies of food preference, two or more foods are made continuously available, positions of the food choices are rotated and food intake is measured. Preference is inferred from the consistent choice of one food over another. Young (1977) describes two types of preference, one based on palatability and one based on biological need. It was his belief that biological needs influence, but do not dictate, palatability. For example, an animal with a particular vitamin deficit may find foods with high levels of that vitamin to be more palatable than it might in the absence of that vitamin deficit, but would not necessarily seek out foods with high levels of the vitamin.

Palatability refers to the perceived tastiness or likeability of a particular food and is dependent on one's hedonic response to the food (Young, 1977). More recently, Berridge (1996) described palatability as an affective component of food reward that can

be thought of as a psychological process that incorporates factors such as taste, an individual's physiological state, and learning history.

Hedonic response to foods refers to the amount of pleasure derived from food or the degree to which a food is liked (Young, 1977). Hedonic responses occur on a continuum ranging from pleasant and appetitive to unpleasant and aversive. Hedonic ratings are often inferred from palatability ratings. That is, when a food is rated as likeable, it may be inferred that it has more positive hedonic qualities (e.g., sweeter, creamier). It was Young's (1966) thesis that behavior is motivated and organized, in part, by the hedonic effects of sensory stimulation. The development of preferential behavior is thought to be dependent on hedonic effects of sensory stimulation (Young, 1966).

In animals, palatability and hedonic responses are inferred from specific eating behaviors such as paw licking (pleasant, likeable) or food avoidance (unpleasant, not likeable). In humans, these responses are typically assessed by subjective ratings. Sensory specific satiety (SSS) refers to the process whereby repeated presentations of a food item will result in decreased liking of that food (habituation) or decreased consumption of the food due to changes in sensory factors (Wisniewski, Epstein, & Caggiula, 1992). Habituation in SSS is specific to a particular sensory quality of the food, and therefore desire recovers with the presentation of a novel food item (Wisniewski et al., 1992).

The research reviewed utilizes both laboratory taste test and free-eating paradigms with both human and rat samples. The human study samples vary from

normal weight college men to obese women. Many of the taste parameters have been studied only in a particular population, and it is the exception that a taste parameter has been compared

between different populations. It will become clear that for the most part, interesting findings with regard to taste have emerged separately among normal weight participants and among overweight individuals, and much more work remains to be done to examine potential differences between the groups.

Taste Preference

Beginning with the early work of Richter (1943) and P. T. Young (1948), there is an extensive animal literature examining food preferences (Richter, 1943; Young, 1948b). This work is reviewed extensively elsewhere (Booth, 1982; Rozin, 1976; Rozin & Schulkin, 1990). For example, Sclafani and Nissenbaum (1988) reported the development of robust and reliable food preferences in rats. In addition, heightened responsiveness to a high fat diet has been detected in genetically obese Zucker rats (Sclafani, 1985).

Rozin (1996) described the human literature on food choice as modest-sized and preliminary. Enhanced hedonic responses to high fat foods have been proposed as a potential mechanism that underlies expression of obesity in humans and animals (Drewnowski, 1996). While it is beyond the scope of the current paper to review the creation of food preferences in children, it is important to note the existence of innate and learned aspects of food preferences (Birch, 1987). Preferences for sweet tastes are known to exist in newborns across many species (Hetherington & Rolls, 1996). The

process of acquiring additional food preferences appears to occur in stages and includes the pairing of postingestive consequences with certain tastes (Hetherington & Rolls, 1996). For example, fat appears to be, at least in part, an acquired taste that develops after an

individual begins to associate fat with feeling full (Hetherington & Rolls, 1996). Immediate and delayed consequences are associated with the smell and taste of foods consumed by young children (Hetherington & Rolls, 1996).

The majority of taste research examining differences between obese and normal weights has been limited to the role of sweet tastes on preference for and consumption of foods. Drewnowski (1985) has reviewed this literature. Sensitivity to sweet flavors has been described as biologically adaptive, as it makes the recognition of high-energy carbohydrates possible (Young, 1977). Increasingly sedentary lifestyles among humans may have changed this advantage into a disadvantage, as energy needs decreased concomitant with increased food availability.

Differential responses to sweet tastes have been found between normal weight and overweight individuals. For example, a glucose preload following a 12 hour fast resulted in a decreased liking for sucrose solutions among normal weight individuals, while likeability of the sucrose solution among obese individuals remained unchanged (Cabanac & Duclaux, 1970). Normal weight individuals lost their “appetite” for sweet solutions after exposure, whereas obese individuals did not (Cabanac & Fantino, 1977). These findings suggest that overeating, obesity, and heightened sweet taste responsiveness may be associated.

Grinker (1978) attempted to tease apart whether the differences between the weight groups on hedonic ratings of sweet solutions were due to a difference in perception of sweetness or difference in preference for sweetness. Overweight individuals rated the sweeter option less pleasant than the normal weight individuals and they consumed less of the sweeter beverage (Grinker, 1978). These results are consistent with Schachter and Rodin's (1974) finding that overweight individuals will eat more of a preferred food, but less of food that they find unpleasant than normal weight individuals will eat (Schachter & Rodin, 1974).

The presence of a "sweet tooth" or hyperresponsivity to sweet foods was once thought to be the primary cause of obesity (Drewnowski et al., 1985). Carbohydrates were blamed for excess weight gain. Some researchers went so far as to look for a chemical basis for the differential responsiveness to sweets proposed to exist between obese and normal weight individuals (Wurtman, 1984). For example, Wurtman (1984) proposed the serotonin-hypothesis of obesity, suggesting that obese individuals suffered from an underlying serotonin deficit. Self-medication with carbohydrates provides tryptophan, the precursor for serotonin. Therefore, obesity was thought to be a consequence of altered food intake (increased caloric intake from carbohydrates) used to bolster serotonin levels (Wurtman, 1984). Studies of the eating behaviors of obese and normal weight women indicate similar overall dietary composition (carbohydrate, protein, and fat), but greater caloric intake among obese women (Schlundt et al., 1993). Also, treatment with selective serotonin reuptake inhibitors (SSRI's) and other antidepressants has not significantly impacted the weight status of non-depressed obese

individuals (Mayer & Walsh, 1998). These findings suggest that excessive carbohydrate intake alone is not the sole cause of obesity in most individuals.

Fat preference

Drewnowski and colleagues (1992) proposed that a preference for high fat, not sweet tastes (carbohydrates), may be a fundamental feature of obesity. However, relative to sweet tastes, much less work has been done examining the role of fat on preference for foods and consumption of foods (Rozin, 1996). In the work that has been done, differences were found between obese and other groups in their response to high fat food items. For example, obese individuals, but not individuals meeting criteria for anorexia nervosa, sought out fat-rich foods when given the opportunity (Drewnowski, 1991). In addition to the nature of the food stimulus, fat preferences also were influenced by subject characteristics (Drewnowski, 1993). In women, hedonic responsiveness was associated with current body weight, dieting history, and the presence of bulimia nervosa or anorexia nervosa (Drewnowski, 1993). In a study examining preferences for varying levels of sugar and fat in dairy products among women, Drewnowski (1993) found that preferences for sweet tastes relative to fat content varied inversely with body fatness. Anorectic women preferred sweet, nonfat foods, but obese women preferred foods that were rich in fat and low in sugar. These effects were even more pronounced among obese women who had a history of weight fluctuations (Drewnowski et al., 1992b).

In rats, fat preferences have been linked to early feeding history and are resistant to change, even after a forced shift to a low fat diet (Warwick, Schiffman, & Anderson, 1990). These findings have important implications for human obesity treatment where adherence to low fat diets is a major concern. It may be useful to examine the

relationship between early feeding history and fat preferences in humans. If fat preferences in humans are also resistant to change, then the use of fat substitutes among obese individuals attempting to lose weight would be warranted. In fact, individual profiles of fat sensitivity and fat preference may provide a useful experimental marker of

an individual's responsiveness and adherence to a low fat diet.

Palatability and Consumption

Sensory characteristics including palatability, flavor, and taste largely influence food selection and total caloric intake in humans (Carmody, Matarazzo, & Istvan, 1987). Not surprisingly, food consumption increases with increased palatability (Geiselman, 1988; Geiselman & Novin, 1982; Spitzer & Rodin, 1981). Rozin (1990b) reviewed the role of social influence on the development of liking for innately unpalatable food and concluded that the meaning of food (as a source of pleasure and/or a source of nutrition) is culturally determined and that beliefs surrounding foods impact human consumption.

The variable that has most consistently differentiated the amount eaten between normal weight and overweight individuals is palatability (Spitzer & Rodin, 1981). Relative to normal weight individuals, increased consumption in response to highly palatable foods is even more pronounced among obese individuals (Spitzer & Rodin, 1981). Based on work with rats, Sclafani (1990) proposed enhanced responsiveness to palatable foods as a cause of dietary-induced obesity in humans and animals. One potential mechanism for overeating and weight gain may be a reduced ability to associate food flavor with fat calories (Warwick, Bowen, & Synowski, 1997). That is, individuals with a greater ability to detect the presence of fat in foods may alter their food intake to eat less when eating high fat foods. Individuals who are not able to detect the presence of fat would be unable to moderate their food intake based on fat content and may be more likely to exceed desired kilocaloric levels.

It has been argued that foods containing both fat and sugar are highly palatable. When rats are exposed to a "supermarket" diet where a number of high-sugar/high-fat

foods are available, dietary consumption increases 50-100% (Sclafani, 1989). Humans consuming high-sugar/high-fat foods require twice as many calories to achieve satiation than humans consuming either savory/high-fat or savory/low-fat foods (Green, Delargy, Joanes, & Blundell, 1997).

Hedonics and Consumption

Do obese individuals obtain more pleasure from food and eating than do normal weight individuals? It is important to note that pleasure is not a quality of food, but instead is something that is derived from food and the experience of eating (Hetherington & Rolls, 1996). Pleasure is central to eating and impacts the development of food preferences, guides the selection of specific foods, aids in the association between flavors and postingestive consequences, and influences when eating is terminated (Hetherington, 1993). The experience of pleasure from eating may be skewed in people suffering from eating disorders or obesity such that negative beliefs surrounding self or food may inhibit the individual's ability to enjoy typical meal consumption. The expectation of receiving pleasure from food may then lead to over-consumption in situations when pleasure is not obtained from eating.

This understanding of pleasure is important because food choices are influenced by both immediate and delayed hedonic effects of the food (Young, 1977). That is, food consumption is initially determined by an individual's immediate response to a particular food, and further influenced by the individual's perceived reactions to its consumption in the long run. Berridge (1996) delineates two components of pleasure derived from eating: liking and wanting. "Liking" of foods has been examined in studies that measured pleasure responses in animals (e.g., licking paws) and subjective ratings among

humans (Berridge, 1996). In contrast, "wanting" has been assessed in animals by a willingness to work for a food (incentive) and the reported desire to eat (appetite) in humans. Although hedonics are known to be influenced by need state (a component of "wanting"), the concept of "liking" plays a critical role in hedonic ratings and hedonic responses to foods originate after any sensory contact with the food (Hetherington & Rolls, 1996).

Data from studies that examined hedonic ratings of sweet tastes among normal and obese individuals yield conflicting results. A relatively greater "liking" of sweet tastes among moderately obese individuals has been reported by some (Cabanac & Duclaux, 1970; Rodin, Moskowitz, & Bray, 1976; Wooley, Wooley, & Dunham, 1972), but not reported by others (Grinker, Hirsch, & Smith, 1972; Grinker, 1978; Grinker, Price, & Greenwood, 1976; Malcolm, O'Neil, Hirsch, Currey, & Moskowitz, 1980; Underwood, Belton, & Hulme, 1973). Drewnowski, Brunzell, Iveruis, and Greenwood (1985) cite methodological discrepancies to explain these inconsistent findings. Specifically, studies using sugar solutions instead of everyday foods containing sugar (and frequently fat as well) found greater hedonic response to sweet tastes among overweight individuals, relative to normal weights (Drewnowski, et al., 1985).

Looy and Weingarten (1991) found that effects of food deprivation on reactivity to sweet tastes are mediated by the individual's hedonic response to sweet flavors. For those individuals whose hedonic response to sweet flavors increased as the sugar content increased, metabolic state did not predict changes in either reported sweet intensity or hedonics (Looy & Weingarten, 1991). Conversely, individuals for whom increased sugar concentration meant decreased hedonic ratings, reported an accentuated dislike for sweet

tastes when deprived. Therefore, both hedonic ratings and metabolic state are important factors to consider when examining taste preferences and consumption.

Sensory Specific Satiety

Eating behavior in humans and other animals is affected by many factors, including sensory perceptions. A phenomenon that illustrates the influence of sensory factors on eating behavior in both humans and animals is sensory specific satiety (SSS). The theoretical underpinnings of SSS began when repeated exposures to particular foods were found to decrease preference for those foods over time (Siegal, 1957). Cabanac (1971) coined the term "alliesthesia" to describe the impact of need state on pleasantness of foods. After food deprivation, the pleasantness of a gustatory experience was greater than when the subjects were not deprived (Cabanac, 1979). Rolls and colleagues (1981) expanded on the concepts of monotony and alliesthesia and developed the idea of SSS, which describes how repeated exposure to a food within a meal also leads to decreased pleasantness specific to that food. Recovery of sensory ratings occur when a new food is introduced (Rolls, 1986). Therefore, SSS is a dynamic aspect of pleasure from eating that can be reflected in eating behaviors (rate of eating), choices between foods, or subjective ratings on the hedonic qualities of foods (Rolls, 1986).

More recently, SSS has been examined in specific populations. For example, within a sample of normal weight male college students, both hedonic ratings and salivation declined with repeated consumption of a palatable food stimuli (Wisniewski, et al., 1992). The presentation of a novel food stimulus resulted in hedonic and salivary recovery, independent of reported hunger or fullness (Wisniewski, et al., 1992). Some evidence was found to support texture specific satiety in a normal weight college sample

(Guinard & Brun, 1998). That is, the pleasantness of the texture and desire to eat hard test foods decreased after eating a hard lunch food (Guinard & Brun, 1998). Similarly, the rated pleasantness and desireablity of soft test foods decreased after eating a soft lunch food (Guinard & Brun, 1998).

SSS appears to operate by influencing the selection of foods within a meal, but does not appear to affect subsequent meals (Rolls, 1986). In addition, SSS may influence the ending of a given meal where a limited number of foods are available, by signaling satiety. Because food selection and meal termination are important factors in weight management, an understanding of the effects of SSS among overweight individuals might provide therapeutic insight. That is, understanding factors that contribute to satiety, food selection and meal termination might lead to an enhanced ability to change these factors. Some work has compared SSS in restrained and unrestrained eaters, but neither differences in magnitude or expression of SSS were found between the groups (Tepper, 1992). In other words, cognitive "restraint" did not alter hedonic responses (Tepper, 1992). Whether or not SSS acts differently in obese and normal weight individuals, independent of restraint status, is not known. It has been hypothesized that studies of SSS may contribute to enhanced understanding of extreme eating behaviors (such as starving oneself and bingeing) in eating disordered individuals (Hetherington, 1993).

Summary

Taste may play a differentially important role in food consumption of obese and normal weight women. It seems that initial studies examining differences between obese and normal weight individuals looked at simple taste parameters (e.g., sweet perception and sweet preference). These efforts were then abandoned to search for differences in

restrained and unrestrained eaters. Taste parameters in obese and normal weight individuals were never fully examined. The current set of studies seeks to fill in these gaps in the research by focusing on taste factors among obese and normal weight women. Women were chosen as the focus of study because women are disproportionately affected by problems of obesity (NIH, 1998). In addition, the eating behaviors of men and women differ indicating that obesity may develop for different reasons among women.

Present Study

A series of studies were conducted to compare overweight and normal weight women on three key dimensions of taste perceptions: fat preference, functional aspects of eating, and sensory specific satiety (SSS). Food consumption has been predicted by the pleasure obtained from foods and may serve to identify individuals at risk for gaining weight (Drewnowski, 1996). It was predicted that, relative to normal weight women, overweight women would rate taste as a more important reason to eat. This hypothesis was based on Schachter's Theory of Externality, which held that overweight individuals would eat more of a highly palatable food and less of an unpleasantly flavored food than normal weight individuals (Schachter, 1971).

In the current investigation, SSS refers to the process whereby repeated presentations of a food item result in decreased liking and desire that will recover with the presentation of a novel food item. The functional aspects of eating included taste ratings, feeling full, and removal of hunger. Parameters were examined at separate meal times (breakfast, lunch, dinner and snacks) and during laboratory taste tests. These three functions of eating (taste, feeling full, and removal of hunger) were examined for breakfast, lunch, dinner, and snacks.

Specific Aims

This study had three specific aims, corresponding to the three key dimensions of taste perception: fat preference, functional aspects of eating, and sensory specific satiety. These aims and corresponding hypotheses are delineated below.

Fat Preference.

Hypothesis 1: Overweight, individuals, relative to normal weight individuals, were expected to consume more of their calories from fat.

Hypothesis 2: If food preferences in daily life were reflected in the laboratory, then overweight women would perceive high fat foods as more pleasant than would normal weight women. This increased preference for high fat foods could have a significant impact on the development and maintenance of obesity given the high caloric density of fat because fat has twice the caloric value as carbohydrate or protein. Because preferences for foods are, in part, determined by the hedonic qualities of foods, overweight women were expected to rate the hedonic qualities of high fat pudding (sweetness, creaminess, flavor, likeability, and desire for more) more positively than would the normal weight women.

Hypothesis 3: Obese women also were expected to rate the hedonic qualities of low fat pudding as less positive than would the normal weight women.

Hypothesis 4: Previous work has reported a positive correlation between percentage of body fat and preference for fat in foods (Mela & Sacchetti, 1991). In the current investigation dietary fat was expected to be associated with hedonic ratings such that obese and normal weight women with a lower percentage of dietary fat were expected to rate the low fat pudding as more flavorful and desirable than individuals with

higher dietary fat intake.

Hypothesis 5: Similarly, assuming that preferences for fat will be reflected in hedonic ratings, degree of overweight was expected to correlate positively with hedonic ratings of the high fat pudding.

Functional Aspects of Food

A functional analysis of eating behavior indicated that many obese women utilize food for more than nutritional purposes (Sbrocco, Kalupa, Stone, Nedegaard, & Lewis, 1999). To understand obesity it may be important to examine potential differences in how overweight and normal weight women use food. The current study examined three potential functions of food: "enjoying the taste," "feeling full," and "removal of hunger."

Hypothesis 1: Obese women were expected to rate the "taste" of food and eating to "feel full" as more important reasons to eat than would normal weight women. Eating for enjoyment and eating to feel full may be better conceptualized as eating functions allowable only in an environment where food is plentiful and where eating is not simply driven by nutritional need.

Hypothesis 2: Normal weight women were expected to report eating to "remove hunger" as more important than would the overweight women. Removal of hunger is based on reducing an internal drive and key to survival.

Sensory Specific Satiety

Sensory specific satiety and recovery could be potential mechanisms to explain why overweight individuals are more likely to overeat in situations were a variety of foods are available. SSS is though to have an important influence on food selection and meal termination. If SSS and recovery occur more dramatically and rapidly among obese individuals, then they would need to eat more foods in order to achieve the same hedonic

value from eating.

Hypothesis 1: Obese women were expected to habituate more quickly to a specific flavor than normal weight women.

Hypothesis 2: After habituation, obese women were expected to show greater recovery of sensory function with the introduction of a novel flavor.

Methods

Participants

Forty-three nonsmoking women (16 normal weight and 27 obese), ages 18-55 were recruited by advertisement from the Washington, D.C., metropolitan area. Women 30-60% above ideal body weight (IBW: Metropolitan Life Insurance Company Height Weight charts, 1983) were recruited to participate in a 13-week weight management program. Age- and ethnicity-matched normal weight women (IBW range: 90 to 110%) were recruited to participate in a study on eating patterns. All participants were paid $50, were required to be free of major medical problems (e.g., hypertension, diabetes), and were excluded if they lost more than 10 lbs. (4.54 kg) in the past month or 20 lbs. (9.09 kg) in the past 6 months. To qualify for participation in the weight loss study, overweight women were required to keep a 2-week eating diary.

Measures

Anthropomorphic Measures. Weight in pounds was measured on a Detecto brand balance beam scale (model 3P704) at session 1 and two weeks later at session 2. Height, to the nearest ½ inch, was measured. Body mass index (BMI) in kg/m^2 was calculated from weight and height measurements.

Dietary Intake. Participants kept 2-week computerized self-monitoring food diaries using Psion 3.0 A palmtop computers (Psion PLC, 1994). Participants were asked not to alter their typical eating patterns during this period of self-monitoring. Computer based self-monitoring has been shown to be a more reliable way to monitor food intake than hand written food diaries (Sbrocco et al., in press). Dietary intake was recorded using the Comcard Compute-A-Diet Nutrient Balance System (1994) software program that contains almost 4,000 foods from the United States Department of Agriculture database (Software Comcard Ltd., 1994). Participants weighed all foods in grams or ounces using Healthometer brand 16 ounce capacity (model 3222) portable scales and recorded food intake in the Psion. Caloric data from these logs were summarized using the Comcard software program. Mean caloric intake and percentages of calories from fat, carbohydrate, and protein were calculated.

Flavor Questionnaire. The Flavor Questionnaire (Warwick & Sbrocco, 1995) consists of 22-items related to the function of eating and the importance of taste (see Appendix A). It was developed to evaluate several aspects of taste and eating, including the frequency of cravings, current hunger ratings and functions of eating. Functions of eating questions asked participants to rate the importance of taste, feeling full, and alleviating hunger during breakfast, lunch, dinner, and snack times. Participants rated their responses on 10-cm visual analog scales (VAS) anchored by “Not at all” and “Extremely.”

Pudding Taste Test. Prior to the arrival of the participants, four pudding samples (two high and two low fat) were prepared for each participant using JELLO-brand vanilla

pudding (see Appendix B). The high fat pudding, made with half-and-half dairy creamer, was 66% fat. The low fat pudding, made with skim milk, was 0% fat. Two drops of yellow food coloring were added to the low fat pudding so that its color matched the high fat pudding. 15-ml plastic cups were filled with pudding and were then chilled.

Participants received a rating booklet with four individual sheets, one spoon, and a pencil before the taste test began. They completed one page of the rating booklet for each sample tasted (see Appendix C). Participants rated sweetness, creaminess, flavor, and likeability of two high-fat and two low-fat samples on 10-cm visual analog scales anchored by "Not at all" and "Extremely." In addition, on a separate 10-cm visual analog scale (anchored with "None" and "A lot"), they indicated how much more of the sample they could eat. In all cases, a higher rating indicated a more positive response. The puddings for all individuals were distributed in the same order: high fat, low fat, low fat, high fat. Participants were not required to eat the entire sample, but instead were asked to try each sample and to eat as much as they liked. Palate was not cleansed between trials because adequate time was allowed between trials to allow for sensory recovery. Once they rated the sample, they were provided with the next sample. The entire taste test took 8-10 minutes to complete.

Sensory Specific Satiety Taste Test (SSS). Participants rated the sweetness, flavor, and likeability of 16 samples of a sweetened flavored (lemon or almond extract) water solution on VAS anchored by "Not at all" and "Extremely" (see Appendix D). Half of the participants received 15 lemon-flavored solutions and the other half received 15 almond solutions followed by a 16th solution that was the opposite flavor. The two

different orders of solutions were utilized (almond-lemon and lemon-almond) in order to rule out any order effects of the particular flavors used. Almond and lemon flavors were chosen because they were assumed to be relatively likeable, neutral flavors. Almond was chosen to represent a relatively novel flavor, whereas, lemon represented a more common flavor. Samples were prepared with NutraSweet, flavor extracts, and water and then chilled and poured into 15ml medicine cups for administration. Participants received a tray with 16 samples in order and a 16 page numbered response booklet. Participants were asked to taste each sample, but were not required to drink the entire 15-ml sample. Ratings were made at 1-minute intervals cued by an experimenter.

Procedure

Participants were phone-screened on age, weight, and health status. Those meeting initial criteria were scheduled for two group meetings, held two weeks apart. Normal weight and overweight women met separately, in groups of four to eight participants. At the first meeting, participants were weighed, the study was explained, and informed consent was obtained (see Appendix E for Informed Consent Form). In addition, the Flavor questionnaire and the SSS test were administered. Participants were instructed to be silent during the tests and to avoid facial expressions that would reveal their ratings and potentially influence the ratings of other participants. After the SSS, the participants received 1½ hours of instruction on the use of the Psion, a computerized eating diary (see Appendix F). Participants were given Healthometer brand (model 3222) portable dietetic scales and instructed to weigh all foods and caloric beverages consumed for 2-weeks. They were instructed that the purpose of the study was to understand

typical eating patterns and, therefore, it was important that they not change their eating behavior during the study. In addition, they were instructed not to try to lose weight.

Upon completion of 2-week food diaries, participants returned for the second meeting. At this time, participants returned the Psion palmtop computer and completed a second Flavor Questionnaire (see Appendix A). Pudding taste tests were then conducted for the normal weight participants. Pudding taste tests for the obese women occurred at the first treatment session. Aside from a 1-week delay, procedures for the pudding taste tests did not differ between the normal weight and obese women. Before the tasting began, subjects were instructed to be silent during the test and to avoid facial expressions or gestures that would reveal their opinions about the pudding to the other participants.

Results

Demographic Information and Food-Intake

Demographic information and results from the 2-week eating diaries are presented in Tables 1 and 2. Normal weight and obese women significantly differed on BMI and estimated food intake (see Tables 1 & 2). They did not differ on age, ethnicity, employment status, or level of education. Surprisingly, they did not differ on percentage of dietary fat intake.

BMI, Food Intake Information, and Hedonic Ratings

Table 3 presents a correlation matrix of the relationships between BMI, dietary intake, and hedonic ratings of high and low fat puddings. BMI was positively correlated with kilocalories consumed during baseline, ($r = 0.41$, $p < .05$), but not with the percentage of dietary fat intake at baseline, ($r = 0.13$, $p > .05$). BMI was negatively

correlated with the sweetness ratings for the low fat pudding, ($r = -0.32$, $p < .05$), but was otherwise unrelated to hedonic ratings for both high and low fat puddings. Interestingly, baseline fat intake was positively correlated with how likeable ($r = 0.32$, $p < .05$) and desirable ($r = 0.32$, $p < .05$) high fat pudding was rated, but not with how sweet ($r = 0.17$, $p > .05$), creamy ($r = 0.19$, $p > .05$), or flavorful ($r = 31$, $p > .05$) it was perceived. In contrast, baseline fat intake was positively correlated with how creamy the low fat pudding was rated, ($r = 0.34$, $p < .05$), but not with any other hedonic rating of the low fat pudding.

Associations among Hedonic Ratings

Sweet and creamy ratings for the high fat pudding were positively correlated with flavor ratings for the high fat pudding ($r = 0.50$, $p < .05$; $r = .43$, $p < .05$, respectively). Creaminess, but not sweetness, ratings for high fat pudding were positively correlated with ratings of likeability ($r = 0.48$, $p < .05$; $r = 0.27$, $p > .05$, respectively) and with desire for more ($r = .0.39$, $p < .05$; $r = .26$, $p > .05$) high fat pudding. Although, perceived sweetness and creaminess were related to flavor ratings of the high fat pudding, only creaminess was related to likeability and desire for more, suggesting the potential role of fat in determining both palatability and consumption of high fat pudding. Flavor ratings of high fat pudding were positively correlated with likeability ($r = 0.79$, $p < .05$) and desire for more ($r = 0.65$, $p < .05$) ratings of the high fat pudding. Also, likeability ratings were positively correlated with desire for more high fat pudding, ($r = 0.88$, $p < .05$). There were no other significant correlations among the hedonic ratings of the high fat pudding.

Sweetness and creaminess ratings for low fat pudding were positively correlated to the flavor of low fat pudding ($r = 0.46$, $p < .05$; $r = 0.39$, $p < .05$, respectively). Creaminess, but not sweet ratings were correlated with likeability ($r = 0.39$, $p < .05$; $r = 0.25$, $p > .05$) and desire for more ($r = 0.42$, $p < .05$; $r = .08$, $p > .05$) low fat pudding. Although, perceived sweetness and creaminess were related to flavor ratings of the low fat pudding, only creaminess was related to likeability and desire for more, suggesting the potential role of fat in determining both palatability and consumption of low fat pudding. Flavor ratings of low fat pudding were positively correlated with both likeability

($r = 0.82$, $p < .05$) and desire for more ($r = 0.67$, $p < .05$). In addition, likeability ratings of low fat pudding were positively correlated with desire for more low fat pudding, ($r = 0. 88$, $p < .05$).

Hedonics and Fat Preference: Pudding Taste Test

Table 4 presents separate hedonic ratings of high and low fat pudding by obese and normal weight women at two time points. Table 5 presents hedonic ratings of high and low fat pudding collapsed across weight groups at two time points. Within groups t-tests failed to reveal significant differences in hedonic ratings between time 1 and time 2 (see Table 5). Because hedonic ratings did not differ across time points, hedonic ratings were collapsed within type (high fat; low fat). A 2-(high fat; low fat) X 2(obese or normal weight) mixed ANOVA was used to examine differences in reported hedonic qualities of pudding.

Table 6 presents hedonic ratings for obese, normal weight, and combined (all subjects) averaged across the two time points. There were no group by pudding type interactions for the five hedonic ratings on: sweetness (F (1,38) = .16, p > .05); creaminess (F (1,38) = 1.72, p > .05); flavorful (F (1,37) = 1.24, p > .05); likeability (F (1,38) = .48, p >. 05); or desire for more (F (1,38) = 3.08, p >. 05). There were no main effects for group on: sweetness (F (1, 38) = 2.05, p > .05), creaminess (F (1,38) = .67, p > .05), flavorful (F (1,37) = .07, p > .05); likeability (F (1,38) = .78, p > .05); or desire for more (F (1,38) = .03, p > .05). There were main effects for pudding type on hedonic ratings. Both groups rated the high fat pudding as creamier, (F (1,38)=104.70, p < .05); more flavorful, (F (1,37) = 24.80, p < .05); and more likeable, (F (1,38)=20.52, p < .05) and there was a trend for higher sweetness ratings, (F (1,38)= 3.75, p = .06). Both groups also indicated they wanted more high fat than low fat pudding, F (1,38)=20.18, p < .05.

Function of Eating: Flavor Questionnaire

A 2 (group) X 4 (meal time) ANOVA was used to compare the groups on the importance of taste, the importance of feeling full as a result of eating, and the importance of alleviating hunger as a reason to eat for each meal time (breakfast, lunch, dinner, snacks). Table 7 presents the mean ratings for these variables. There were no significant interactions between group and mealtime on the rated importance of taste, feeling full or alleviating hunger. Alleviating hunger was rated as a less important reason to eat snacks than at any of the primary meal times. Feeling full was a more important function at breakfast, lunch and dinner, than at snack time.

Groups did not differ on the importance of "*taste"* as a reason to eat. Taste was a highly rated reason to eat for obese and normal weights, especially at dinnertime. Obese women rated "*feeling full"* as a significantly more important reason to eat (F (1, 39) = 9.03, $p < .05$) than normal weight women at breakfast, lunch, and dinner. Similarly, obese women rated the importance of "*alleviating hunger"* as greater than normal weight women at breakfast (t (41)=3.01, $p < .05$), lunch (t (41)=3.06, $p < .05$), and dinner (t (40)=3.45, $p < .05$).

Sensory Specific Satiety

SSS data are presented for sweetness, flavor, and likeability ratings for the almond-lemon (AL) and lemon-almond (LA) separately in Figures 1-6. Figures 1 and 2 present sweetness ratings across 16-time points for the almond-lemon and lemon almond group, respectively. Figures 3 and 4 present flavor ratings across 16 time points for almond-lemon and lemon-almond solutions. Figures 5 and 6 present likeability ratings

for the same solutions at 16 time points. Visual analysis of the graphs provided the remainder of the SSS results since trends were the desired level of analysis and these data were based on a small sample.

Sweetness. The obese women's sweetness ratings habituated much more quickly than did the normal weight women's sweetness ratings for both AL and LA (see Figures 1 and 2). They also showed recovery for sweetness with the introduction of the novel lemon flavor. The normal weight women habituated slightly and did not appear to recover with the novel flavor. Obese rated the two conditions as similarly sweet. An independent groups t-test revealed a trend for lower mean sweetness rating for the almond-lemon order of solutions than the lemon-almond order among the normal weights (t (14) = -2.12, p. = .053). A more dramatic recovery for sweetness occurred in the obese women when switching from almond to lemon than when switching from lemon to almond flavored solutions.

Flavor. Flavor ratings changed little for both groups and consequently, as expected with the absence of habituation, there was no clear recovery to the novel stimulus (see Figures 3&4).

Likeability. Figures 5 and 6 present likeability data for obese and normal weight women. Overall, the obese liked the sweet solutions more than did the normal weights. Given the normal weights' low initial ratings, the ratings could not be expected to habituate. Low initial likeability ratings of both the lemon and almond solutions by the normal weight women indicate a possible floor effect. The obese did not exhibit a clear pattern of habituation though the ratings did appear to decrease after the first ten trials of

the LA condition. Obese women showed recovery for likeability with the introduction of novel almond flavor.

Confirmation of Hypotheses

Fat Preference.

Hypothesis 1: The hypothesis that overweight individuals, relative to normal weight individuals would consume more of their calories from fat was not confirmed.

Results: Two weeks of food diary information revealed significant differences in kilocaloric intake between obese and normal weight women, but no significant differences in dietary fat intake were seen.

Hypothesis 2: The hypothesis that overweight women would perceive high fat pudding as more pleasant, as indexed by higher hedonic ratings, than normal weight women would was not confirmed.

Results: No group by pudding type interactions for the five hedonic ratings of high fat puddings were seen. It may be that some of these experiments lacked sufficient statistical power to detect existing differences between obese and normal weight groups. A post hoc power analysis revealed power ranging from .06-.30 on the various tests. Failure to reject the null hypothesis could be due to a true lack of differences between obese and normal weight women on these taste parameters or evidence of insufficient statistical power. The study could be replicated with more participants to increase power.

Hypothesis 3: The hypothesis that obese women were expected to rate the hedonic qualities of low fat pudding as less positive than the normal weight women was not confirmed.

Results: No group by pudding type interactions for the five hedonic ratings for low fat pudding were seen. It may be that the experiment lacked sufficient power to

detect group differences. A post hoc power analysis revealed power ranging from .06-.30 on the various tests. The study could be replicated with more participants to increase power.

Hypothesis 4: The hypothesis that dietary fat would be associated with hedonic ratings such that women with a lower percent of dietary fat were expected to rate the lower fat pudding as more flavorful and desirable, was partially confirmed.

Results: Baseline fat intake was positively correlated with likeability and desirability ratings for high fat pudding, but not with sweetness, creaminess or flavor ratings of high fat pudding. Baseline fat intake, was however, positively correlated with creaminess ratings of the low fat pudding, but not with sweetness, flavor, likeability or desirability ratings of the low fat pudding.

Hypothesis 5: The hypothesis that degree of overweight was expected to correlate positively with hedonic ratings for the high fat pudding was not confirmed.

Results: BMI was unrelated to hedonic ratings of the high fat pudding. Only sweetness ratings for the low fat pudding were negatively correlated with BMI.

Functional Aspects of Food.

A functional analysis of eating behavior indicated that many obese women utilize food for more than nutritional purposes (Sbrocco, Kalupa, Stone, Nedegaard, & Lewis, 1998). To understand obesity it may be important to examine potential differences in how overweight and normal weight women use food. The current study examined three potential functions of food: "enjoying the taste," "feeling full," and "removal of hunger."

Hypothesis 1: The hypothesis that obese women would rate "taste" of food and

eating “to feel full” as more important reasons to eat than normal weight women was partially confirmed.

Results: “Taste” was a highly rated reason to eat for both obese and normal weight women, especially at dinnertime. Obese women rated “feeling full” as a significantly more important reason to eat than normal weight women for breakfast, lunch, and dinner.

Hypothesis 2: The hypothesis that normal weights would rate eating to “remove hunger” as more important than obese individuals was not confirmed.

Results: In fact, eating to alleviate hunger was rated as a more important function of breakfast, lunch, and dinner for the obese women, relative to the normal weights.

Sensory Specific Habituation and Recovery.

Hypothesis 1: The hypothesis that obese women would habituate more quickly to a specific flavor was partially confirmed.

Results: The obese women’s sweetness ratings habituated more quickly than did the ratings of the normal weight women for both flavor categories. Flavor ratings changed very little for both normal weight and obese participants. Overall, the obese liked the solutions much more than did normal weights. However, obese did not show a clear pattern of habituation, but decreased over the last several trials. The initial likeability ratings of the normal weight women were too low to habituate.

Hypothesis 2: The hypothesis that obese women would show greater recovery of sensory function with the introduction of a new flavor was partially confirmed.

Results: Obese women’s sweetness ratings showed recovery for sweetness with

the introduction of the novel lemon flavor. This recovery was not seen in the normal weight women's sweetness ratings. For flavor ratings, neither group showed clear habituation and therefore could not be expected to recover with the presentation of a novel stimulus. Obese, but not normal weights showed recovery in likeability ratings with the presentation of a novel stimulus.

Discussion

Contrary to our hypotheses, both obese and normal weight women preferred high fat pudding to the low fat pudding. In addition, the two groups did not differ in their hedonic ratings of the pudding characteristics. These findings are consistent with the information from their actual food-intake, which suggests there were no significant differences in dietary composition across groups. If fat preferences in laboratory taste tests are related to actual dietary fat intake, these groups would not be expected to differ on laboratory taste tests because both groups consumed approximately 35% of their kilocalories in fat. Of note, dietary fat intake was just slightly less than the national average (NHANES, 1994) suggesting that these data may be generalizable to overweight adult Americans.

These findings on fat preference highlight the need to understand the impact of dietary modification, particularly lower fat diets, on taste perception and preferences. It may be that taste preferences significantly impact dietary choices and an individual's ability to initiate and maintain dietary changes. For example, many weight reduction programs promote decreasing caloric intake and decreasing the overall percentage of dietary fat to 25% of total caloric intake. The impact that a reduction in dietary fat intake will have on fat preferences is unknown. It may be that as dietary fat decreases, so will preferences for fat. Alternatively, it is possible that fat preference remains unchanged even with reductions in the consumption of dietary fat. The latter situation might contribute to adherence problems, a well-documented phenomenon in dietary literature. In this case, the use of low fat substitutes to maintain "fat-like" characteristics may enhance dietary adherence. By mimicking the sensory qualities of fat, fat substitutes may enhance the palatability of low fat foods, through an altered hedonic experience, without

adding kilocaloric value. Future research should investigate the relationship between dietary modification, fat perception, fat preference and the use of fat substitutes.

Results of the current investigation suggest that everyone, regardless of weight status, liked fat, as indexed by more positive hedonic ratings on sweetness, creaminess, flavor, likeability on the high fat pudding relative to the low fat pudding. This preference for high fat was most dramatic in women with higher baseline fat intake. Because baseline fat intake and BMI were not related, any relationship between dietary fat intake and taste preferences was not a result of weight status. It is not clear if dietary intake is dictated by a high fat taste preference or if dietary intake maintains a learned preference for high fat foods, or if both are true. There does not appear to be differential taste perception between individuals with higher baseline fat intake and those with lower baseline fat intake, as their hedonic ratings of sweetness, creaminess, or flavor did not differ from one another. Only differences in the likeability and desire for more high fat pudding were seen among individuals with different baseline fat intakes. It is not known if fat preference is a malleable phenomenon. Future research should examine the effects of dietary change on fat perception.

The current research suggests that differences in taste preference, but not necessarily taste perception exist between obese and normal weight individuals. It is likely that a complex relationship between multiple factors exists. For example, baseline differences in taste perception and taste preferences may exist at birth and/or develop over time making certain individuals more vulnerable to the development of obesity. There is some evidence that biological differences in taste preference exist. Grunberg (1982), for example, reported differences in taste preference, but not taste perception between smokers, smoking compared with nonsmokers and smokers not smoking.

Grunberg (1986 & 1988) indicated effects of nicotine on insulin that might explain these effects. In the presence of high levels of insulin, hunger would be expected to increase. It may be that food preferences are influenced directly by levels of insulin or indirectly through insulin's effect on hunger. Further, in the face of hunger there would be a biological advantage to consuming high fat versus low fat foods, since they contain more kilocaloric energy. Future research could further examine the relationship between insulin, taste perception, taste preferences and hunger.

The current investigation developed after the investigators noticed a change in reported fat preference over the course of weight loss treatment with overweight women. After placement on a low fat diet, women initially complained about a flavor deficit and general reduction in palatability of their foods. After time many of these women reported feeling nauseous when they returned to eating high fat foods. It may be that nausea coupled with the experience of certain tastes would impact future hedonic rating of those tastes. If this proves to be true, among women who experience nausea when eating high fat foods after several weeks on a low fat diet, one would expect greater long-term adherence to a low fat diet. Depending on the strength of the association between certain tastes and the feelings of nausea, one might even expect reduced hedonic ratings of high fat foods in subsequent taste tests. The digestive agents released in response to eating, such as bile are likely to differ based on the composition of the foods consumed. How digestive enzymes might impact satiety or the experience of taste is not well understood and could be the basis of future investigations.

Additionally, factors that might work to translate biological "vulnerability" into actual expression of obesity are not fully considered in the current investigation. A history of dieting and overeating may further work to alter the experience of taste and

one's hedonic responses to food. It is probable that one's attitudes and beliefs about foods and eating will impact this sensory experience. Future research needs to examine these relationships by including measures of binge eating, dieting history, and cognitive measures relating to the experience of eating.

With regard to the low fat pudding, BMI was inversely correlated with sweetness ratings, suggesting that higher weight status was associated with a decreased perception of sweet taste. BMI was otherwise unrelated to hedonic and preference ratings of the low fat pudding. It is not clear why obese women would have a reduced ability to perceive sweet taste in a low fat pudding sample. It may be that these women were aware of a difference in taste relative to the high fat pudding, but had difficulty identifying what was different and in distinguishing between tastes of sweet and fat. It may also be that obese women's perception of sweet is somehow dependent on the availability of fat in foods. This phenomenon warrants further examination. Future investigations could examine the relationship between sweet and fat perception by offering normal weight and obese women several different food samples with varying levels of fat and sugar to explore the relationship between taste perception for fat and sweet tastes (Drewnowski & Greenwood, 1983).

The Functions of Eating

The results on the function of food suggest that, contrary to expectations, taste was quite important for everyone, not just for the obese women. Taste may be less important for a population that is more focused on eating to survive, for example, individuals where food is in short supply. The current investigation could be repeated among groups of people who do not have ready access to highly palatable, high fat foods. Interestingly, the obese women did find feeling full and alleviating hunger as more

important reasons to eat compared to their normal weight counterparts. If alleviating hunger and achieving satiety are more important in the obese, then it may be that more time and energy is spent on these behaviors among obese women than among normal weight women. It may also be that these differential functions put obese at greater risk for eating "whatever is available" because satiety is such a strong priority. These might be factors that encourage overeating in the obese and are worthy of further examination.

In addition, the relative importance of the three functions of eating (taste, feeling full, and alleviating hunger) changed across meal times. The differentially important functions of eating are clinically relevant because of the potential impact they could have on meal planning. For example, because feeling full was so highly endorsed by obese participants, extra emphasis could be placed on increasing fiber at high-risk meals. The obese may be at greater risk for increasing fat consumption in order to feel full, and fiber would be a healthy, effective substitute. Because taste was so highly rated for dinner and snack times, extra effort could be placed on preparation of these meals to ensure satisfaction.

Sensory Specific Satiety

Sensory specific satiety influences food selection within a meal (Rolls, 1986). Food selection and meal termination are important factors in weight management and these data on SSS in obese individuals might provide important insight into factors that may impede or facilitate successful weight loss. Faster and clearer habituation to sweetness of almond flavoring was evidenced among the obese, relative to the normal weight individuals. Greater recovery of sensory function occurred in the obese, relative to normal weight individuals when a novel stimuli was presented. Although obese individuals stopped perceiving sweet foods as sweet more quickly than did normals, their

taste perception recovered dramatically when food content was altered. This phenomenon could offer one explanation why obese humans and rats tend to overeat in situations where many types of foods are available (Green et al., 1997; Sclafani, 1989). That is, obese individuals may have to eat a greater variety of foods to receive the same hedonic pleasure from foods because they habituate so quickly to certain aspects of taste.

Limitations

The current set of investigations has several limitations. The obese women who participated were seeking treatment for obesity and may represent an important subgroup of obese individuals, without representing obese women as a whole. Generalizability of the results to other groups, such as obese women not seeking treatment or men, is not known. In addition, information on dieting history or a history of weight fluctuations was not obtained. Previous research indicates that individual differences including a history of dieting or weight fluctuations may impact the experience of taste (Drewnowski, 1993). Information on individual differences may help to better tailor weight management programs to meet the needs of its participants. Also, potential ethnic differences in taste perception were not examined and could be considered in future investigations.

Taste stimuli used in the investigations also may limit generalizability. For fat preference and hedonic ratings, only pudding was used. Pudding was selected because previous research indicates the impact of foods high in both fat and sugar on weight gain (Lucas & Sclafani, 1990). If a greater variety of foods were tested, then an understanding of the robustness of the high fat preference could be obtained. For example, it is not clear if individuals prefer high fat in the absence of sugar.

An additional limitation of the current investigation includes the absence of adequate power to detect true group differences. It is difficult to determine if failure to find differences between obese and normal weight women's hedonic responses to high and low fat pudding was due to a lack of group differences or if the tests were simply not sensitive enough to detect a difference. One way to determine if group differences do truly exist would be to replicate with a greater number of subjects in order to increase statistical power.

Future Investigations

The current set of investigation provides a focused snapshot of several taste parameters in a specific group of individuals. The results of these investigations apply to educated, middle-aged women, but do not consider other groups of individuals. Future investigations should address generalizability by including men, women who are not middle aged, and/or children. The majority of the individuals used in the current investigation were Caucasian and future investigations should examine ethnic differences in the experience of taste. Women who are obese, but not seeking treatment for weight loss, also should be considered because they may differ in important ways from obese women who are seeking treatment. Prospective longitudinal studies of taste preferences could be conducted starting in infants and progressing throughout the lifespan. Additionally, cross-sectional research could be used to compare various groups at a given point in time.

To address limitations surrounding the use of simple food stimuli, more complex food stimuli could be used. High fat foods, such as potato chips or cheese, could be tested to determine whether fat preference remained among obese and normal weight women. Flavored solutions were the stimuli in tests of sensory specific satiety. While

the solutions acted as a simple stimulus, findings from the hedonic ratings may not generalize to actual food items. Future investigations could examine the impact of actual foods on sensory specific satiety in obese and normal weight women.

It is not clear if fat preferences are a malleable phenomenon. To test the malleability, individuals could complete two weeks of baseline dietary monitoring and measures of taste perception and preference and then be asked to follow several weeks of a reduced fat diet that did not significantly alter total caloric intake. Measure of taste perception and preference could be repeated after the completion of the reduced fat diet to determine if changes in fat perception were evident.

Another potentially important question surrounds the use of fat substitutes among obese individuals who are trying to lose weight. If clients are instructed to use fat substitutes, are behaviors being encouraged that might negatively impact the maintenance of weight loss? That is, fat substitutes may maintain high fat preferences in the face of dietary change. On the other hand, if clients are instructed to avoid fat substitutes is the likelihood that they will adhere to the weight loss program reduced? These questions remain unanswered and warrant further investigation. More specifically, there may be individual differences in taste responses to dietary change. It may be that certain subgroups of obese individuals have a more robust preference for fat. It is also unclear how a history of dieting behaviors may impact taste preferences.

Another curious phenomenon is the fact that normal weight women ate the same percentage of calories in fat as the obese women, yet their kilocaloric intake remained lower than that of the obese. Mechanisms that facilitate satiety should be further examined in obese and normal weight women because obese women rated this function of food to be more important than did normal weight women. Data from the sensory

specific satiety tests in the current investigation suggest that obese women habituate to some hedonic qualities of food faster than the normal weight women, and therefore, require a greater variety of foods to achieve the same hedonic value that normal weight women achieve. Studies should be conducted to determine if sensory specific satiety could be enhanced among obese women. For example, SSS could be tracked over the course of weight loss treatment to determine the impact of diet change on the experience of satiety. In addition, even though all participants in the current investigation preferred high fat foods, the obese may be more dependent on these foods for reinforcement. Sources of potential and actual reinforcement should be examined among obese and normal weight participants.

Conclusions

This research found some surprising similarities and expected differences between taste perceptions in obese and normal weight women. Most notably, a more thorough examination of these factors may help to provide an understanding of the function that eating in general, and taste in particular, play in the maintenance of dietary change.

Table 1

Demographic Data

	Obese	Normal	Total
Age	41.96 (9.96)	39.75 (11.09)	41.08 (10.35)
Education	14.42 (2.90)	16.23 (2.24)	15.05 (2.80)
Marital Status			
%Married	12 (50%)	8 (50%)	20 (50%)
%Single, never married	5 (21%)	4 (25%)	9 (22.5%)
%Divorced	5 (21%)	4 (25%)	9 (22.5%)
Employment Status			
%Employed	19 (79%)	14 (88%)	33 (82.5 %)
%Full time student	2 (8%)	2 (13%)	3 (7.5%)
%Not employed	3 (13%)	0 (0%)	2 (5.0%)
Ethnicity			
%African American	5 (21%)	5 (31%)	10 (25%)
%Caucasian	17 (71 %)	11 (69%)	28 (70%)
%Hispanic	2 (8%)	0 (0%)	2 (5%)

Note. Age and education presented as mean scores (standard deviation). The remainder of the demographic information is presented as raw score (percentage).

Table 2

Food Diary Information

	Obese M (SD)	Normal M (SD)	Total M(SD)
BMI	32.34 (3.55)	22.14 (2.50)	28.16 (5.97)
% Dietary fat	36% (8.01%)	33% (7.79%)	35% (8.02%)
Kcal	2741.35 (819.81)	2028.38 (665.04)	2448.85 (830.61)

Note. BMI = Body Mass Index in kg/m^2; % Dietary fat = average daily % of dietary fat; Kcal = Average 14-day kilocaloric intake

Table 3

Intercorrelations Between BMI, Food Intake Information, and Hedonic Ratings

	Kcal	**%fat**	**Sweet high**	**Sweet low**	**Creamy high**	**Creamy low**	**Flavor high**	**Flavor low**	**Like high**	**Like Low**	**More high**	**More low**
BMI	**.41****	.13	-.30	**-.32***	-.11	.19	-.15	.05	-.07	.11	-.15	.14
Kcal	--	-.25	-.17	-.14	-.09	.26	-.05	.05	-.00	.13	-.16	.21
%fat		--	.17	.15	.19	**.34***	.31	.27	**.32***	.20	**.32***	.20
Sweet high			--	**.61****	.27	.07	**.50****	**.33***	.27	.16	.26	.16
Sweet low				--	.18	.20	**.43****	**.46****	**.32***	.25	.21	.08
Creamy high					--	.25	**.49****	.28	**.48****	.13	**.39***	.09
Creamy low						--	.30	**.39***	.34	**.39***	.11	**.42****
Flavor high							--	**.58****	**.79****	**.47****	**.65****	**.44****
Flavor low								--	**.50****	**.82****	**.40***	**.67****
Like high									--	**.50****	**.88****	**.51****
Like Low										--	**.44****	**.88****
More high											--	**.52****
More low												--

Note. *p < . 05. **p < .01

Table 4

Mean Hedonic Ratings of High and Low Fat Puddings Presented Separately for Obese and Normal Weight Women at Two Time Points

		High Fat		**Low Fat**	
Hedonic quality		Time 1	Time 2	Time 1	Time 2
Sweet	Obese	47.63(22.13)	47.04(24.36)	40.58(21.14)	40.88(18.56)
	Normal	53.00(21.24)	55.50(23.94)	47.00(22.31)	52.75(22.06)
Creamy	Obese	72.96(16.83)	77.00(15.01)	46.58(27.34)	50.21(18.44)
	Normal	76.50(16.58)	75.06(16.29)	36.31(22.46)	41.06 (22.31)
Flavorful	Obese	55.41(23.43)	55.27(20.44)	42.21(24.69)	40.25(23.81)
	Normal	52.44(25.85)	57.88(19.47)	39.38(24.12)	33.63(20.65)
Likeable	Obese	47.92(29.63)	49.83(22.64)	36.75(26.54)	31.42(22.00)
	Normal	49.50(32.49)	49.88(31.01)	29.69(23.94)	29.38(24.02)
Desirable	Obese	31.25(25.76)	37.21(24.32)	25.38(24.06)	23.46(22.68)
	Normal	44.19(31.49)	38.94(30.64)	19.31(22.02)	19.00(22.17)

Note. There were no significant differences within groups between Time 1 and Time 2 on any of the hedonic ratings. Time 1 refers to the first sample of each pudding type (high and low fat) and Time 2 refers to the second sample of each pudding type.

Table 5

Mean Hedonic Ratings for High and Low Fat Puddings at Two-Time Points for All Participants

	High Fat		Low Fat	
Hedonic quality	Time 1	Time 2	Time 1	Time 2
Sweet	49.78 (21.66)	50.43 (24.25)	43.15 (21.57)	45.63 (20.61)
	t(39) = - .18		t(39) = - .94	
Creamy	74.38 (16.61)	76.22 (15.35)	39.98 (22.20)	46.55 (20.31)
	t(39) = - .73		t(39) = - 1.96	
Flavorful	53.03 (24.89)	55.18 (20.91)	41.08 (24.19)	37.60 (22.56)
	t(38) = - .58		t(39) = 1.03	
Likeable	48.55 (30.40)	49.85 (25.93)	33.92 (25.46)	30.60 (22.55)
	t(39) = - .32		t(39) = 1.08	
Desirable	36.46 (28.53)	37.90 (26.66)	22.95 (23.17)	21.68 (22.30)
	t(39) = - .39		t(39) = .47	

Note. *p < . 05. **p < .01. Time 1 refers to the first sample of each pudding type (high and low fat) and Time 2 refers to the second sample of each pudding type.

Table 6

Summary of Mean Hedonic Ratings for High and Low Fat Puddings

Hedonic Rating	**Obese Mean(SD)**	**Normal Mean(SD)**	**Total Mean(SD)**
SWEETNESS			
High fat	47.33(20.28)	54.25(19.15)	50.10(19.88)
Low fat	40.73(17.72)	49.88(20.98)	44.39(19.37)
Average	44.03(17.89)	52.06(16.53)	47.24(17.60)
CREAMY			
High fat	74.98(13.86)	75.78(14.26)	75.30(13.84)
Low fat	46.31(16.22)	38.69(21.05)	43.26(18.43)
Average	60.65(11.97)	57.23(14.20)	59.28(12.84)
FLAVORFUL			
High fat	53.37(19.80)	55.16(20.55)	54.10(19.86)
Low fat	41.23(20.97)	36.50(20.92)	39.34(20.81)
Average	47.44(18.66)	45.82(17.99)	46.78(18.17)
LIKEABILITY			
High fat	48.88(22.24)	49.69(29.60)	49.20(25.10)
Low fat	34.08(21.52)	29.53(23.11)	32.26(21.99)
Average	41.48(18.91)	39.61(23.01)	40.73(20.38)
DESIRE FOR MORE			
High fat	34.23(21.05)	41.56(29.88)	37.16(29.86)
Low fat	24.42(21.01)	19.16(21.37)	23.31(21.04)
Average	29.32(19.32)	30.36(21.63)	29.74(20.01)

Note. All ratings represent the average between Time 1 and Time 2. Time 1 refers to the first sample of each pudding type (high and low fat) and Time 2 refers to the second sample of each pudding type.

Table 7

Functions of Eating Ratings for Obese and Normal Weight Women at Different Meal Times

	Function of Eating		
Meal	Taste	Fullness	Alleviate Hunger
	Obese[a]		
Breakfast	62.28 (29.15)	66.08 (25.02)	78.84 (19.50)
Lunch	75.16 (20.70)	64.06 (21.18)	79.96 (15.52)
Dinner	81.72 (19.71)	71.76 (18.29)	83.16 (13.73)
Snacks	72.08 (26.43)	49.56 (30.68)	62.88 (23.63)
	Normal[b]		
Breakfast	65.94 (21.31)	44.44 (24.88)	57.89 (26.12)
Lunch	67.61 (21.58)	51.89 (23.20)	62.00 (23.06)
Dinner	79.00 (18.01)	53.88 (22.49)	62.82 (24.44)
Snacks	70.81 (25.97)	39.69 (29.12)	48.06 (31.59)

Note. The values represent M (SD) importance ratings for functions of eating at each meal time.

[a]Obese were 30-60% above ideal body weight (IBW; Metropolitan Insurance). [b]Normal weights were within 90-110% of IBW.

Figures 1-6 Present Sensory Specific Satiety Ratings for Obese and Normal Weight Women

Sweetness Ratings

Figure 1: Almond-Lemon

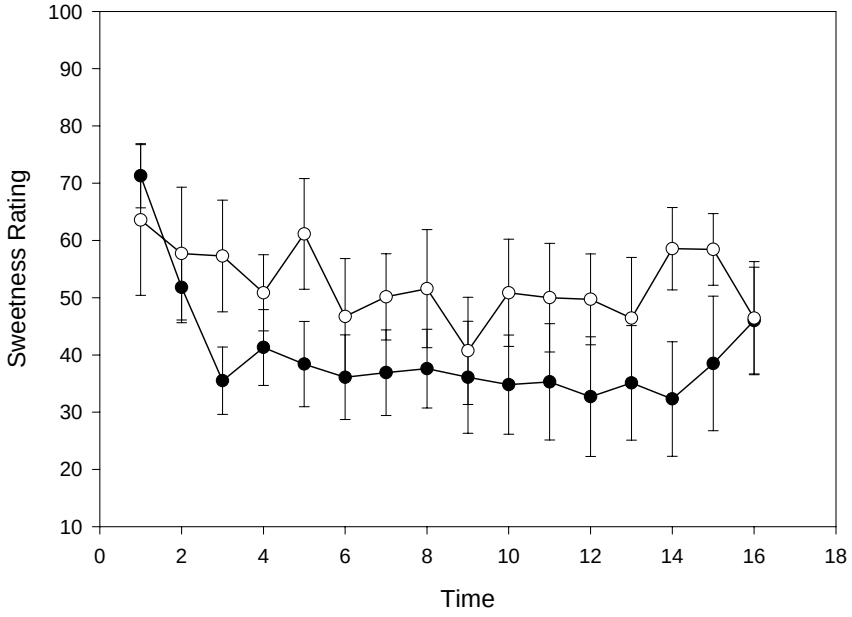
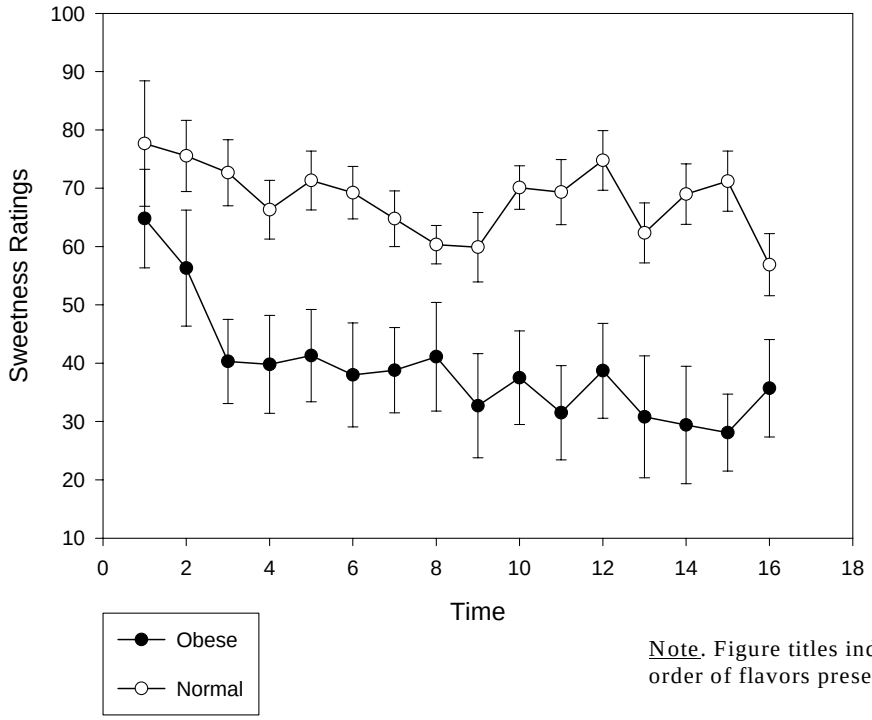


Figure 2: Lemon-Almond



Note. Figure titles indicate the order of flavors presented

Flavor Ratings

Figure 3: Almond-Lemon

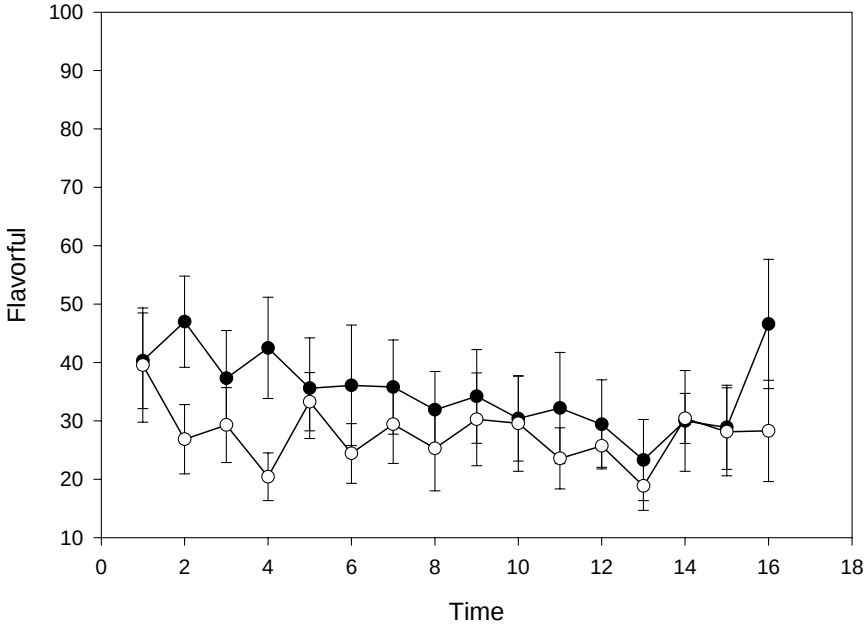
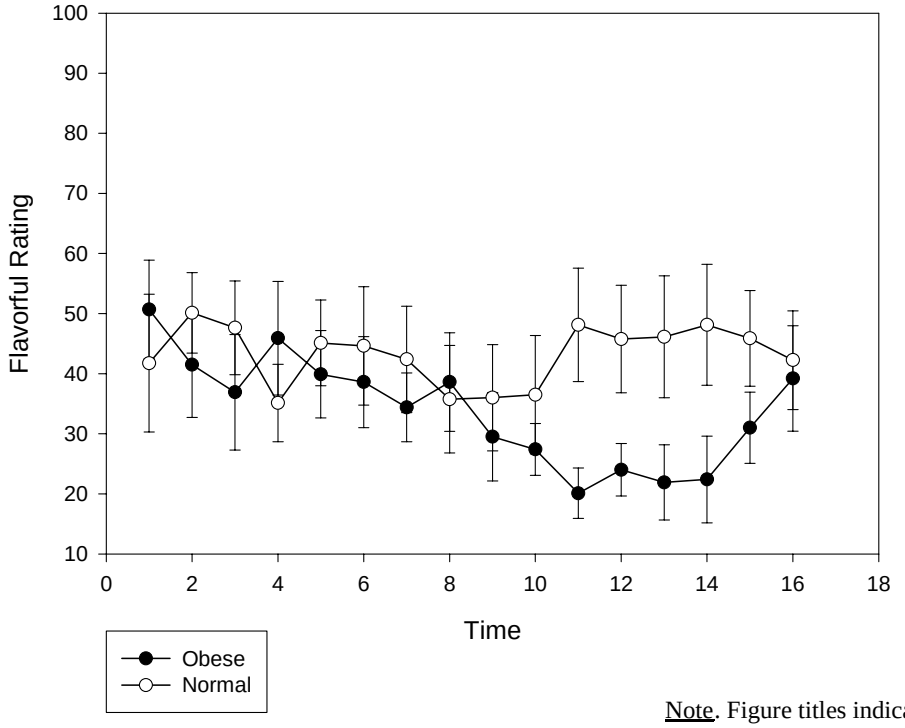


Figure 4: Lemon-Almond



Note. Figure titles indicate the order of flavors presented

Likeability Ratings

Figure 5: Almond-Lemon

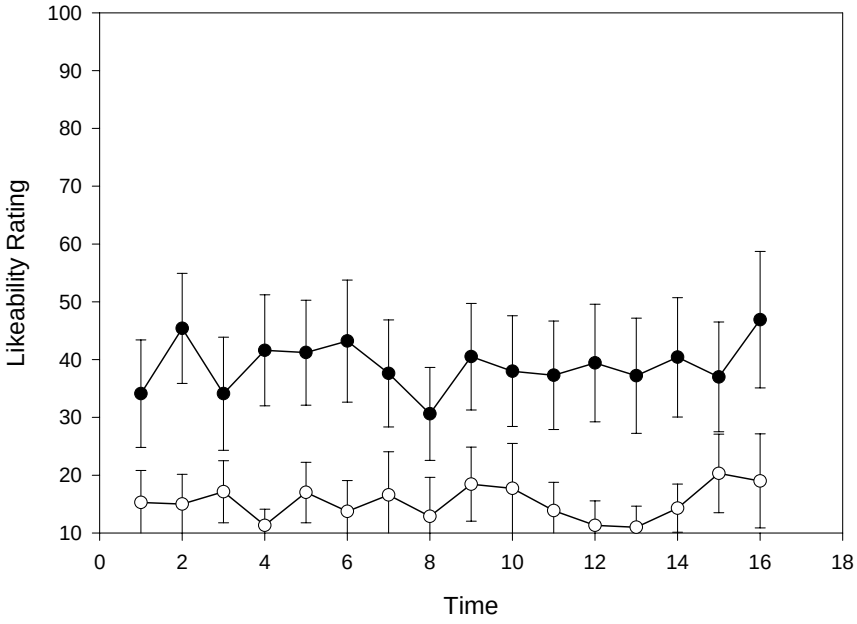
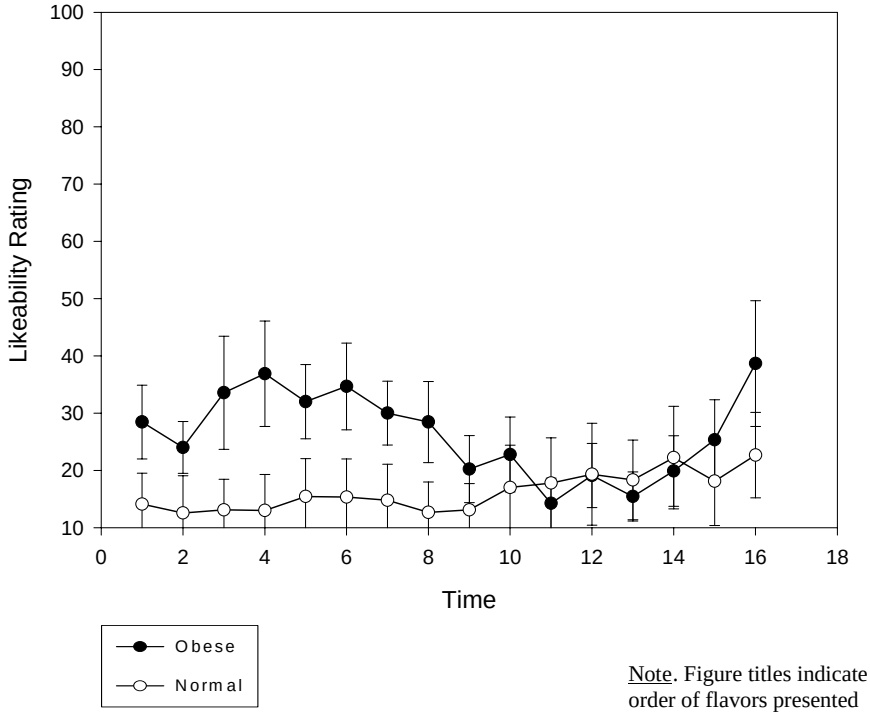


Figure 6: Lemon-Almond



Note. Figure titles indicate the order of flavors presented

Appendix A: Flavor Questionnaire

[FQ1]

Subject #: _____

Date: _____

Time: _____

Instructions: Read the questions on the following two pages carefully. For some questions, your answer will be a number, for some questions, your answer will be a sentence or two, and for some questions, your answer will be a Line Scale Rating. On the Line Scales: just make a mark along the line that indicates the intensity of your feeling. If you are not sure how to use the Line Scale, please ask the Leader.

[FQ2]

Subject # _____ Date: _____

When you eat BREAKFAST,

How important is it to you that your meal have a good taste/flavor?
Not at all _____ Extremely

How important is it to you that your meal gives you a full feeling in your stomach?
Not at all _____ Extremely

How important is it to you that your meal takes away hunger pangs?
Not at all _____ Extremely

When you eat LUNCH,

How important is it to you that your meal have a good taste/flavor?
Not at all _____ Extremely

How important is it to you that your meal gives you a full feeling in your stomach?
Not at all _____ Extremely

How important is it to you that your meal takes away hunger pangs?
Not at all _____ Extremely

When you eat DINNER,

How important is it to you that your meal have a good taste/flavor?
Not at all _____ Extremely

How important is it to you that your meal gives you a full feeling in your stomach?
Not at all _____ Extremely

How important is it to you that your meal takes away hunger pangs?
Not at all _____ Extremely

When you eat a SNACK,

How important is it to you that your meal have a good taste/flavor?
Not at all _____ Extremely

How important is it to you that your meal gives you a full feeling in your stomach?
Not at all _____ Extremely

How important is it to you that your meal takes away hunger pangs?
Not at all _____ Extremely

[FQ3]

Subject # _____ Date: _____

Right now, how ***hungry*** are you?

Not at all _____ Extremely

Right now, how ***tired*** are you?

Not at all _____ Extremely

In the past seven days, approximately how many packets/spoonfuls of low-calorie sweetener (Equal, Sweet 'N Low, Sugar Twin or store brand low-calorie sweetener.) did you use? _____

Think of the BEST-TASTING meal you had this past week. What was it?

How much did you enjoy the TASTE/FLAVOR of this meal?

Not at all _____ Extremely

Think of the WORST-TASTING meal you had this past week. What was it?

How much did you enjoy the TASTE/FLAVOR of this meal?

Not at all _____ Extremely

During the past week did you find yourself strongly wanting or craving a specific food taste/flavor? Yes ____ No ____

If so, what was that food taste/flavor?

Overall, during the past seven days how ***satisfied*** were you by the taste/flavor of the foods you ate?

Not at all _____ Extremely

Appendix B: Pudding Recipes

High fat pudding

Ingredients: 90 grams Jell-O brand instant dry vanilla pudding mix

500 grams Half-and half creamer

Method: Pour some of the half-and-half in a blender, add pudding mix, then add the rest of the half-and half. Add .8 ml of McCormick yellow food coloring. Blend at the lowest speed for 20 seconds. Pour into 30-ml cups and refrigerate.

Low-fat pudding

Ingredients: 90 grams Jell-O brand instant dry vanilla pudding mix

500 grams skim milk

Method: Pour some of the skim milk in a blender, add pudding mix, then add the rest of the skim milk. Blend at lowest speed for 20 seconds. Pour into 30-ml cups and refrigerate.

Appendix C: Hedonic Rating Form for Pudding

Subject #:_____
Sample:_____
Date:_____

Instructions: Taste the pudding sample and complete the ratings below. When you have completed your ratings, turn to the next rating sheet in this booklet and then ask the Leader for your next sample.

How SWEET is this pudding?
Not at all _____Extremely

How CREAMY is this pudding?
Not at all _____Extremely

How FLAVORFUL is this pudding?
Not at all _____ Extremely

How much do you *like* this pudding?
Not at all _____Extremely

If you could eat more of this pudding, how much do you think you would eat?
None _____ A lot

Do you have any comments about this pudding sample? If so, write them in the space below:

Appendix D: Solution Recipes for Sensory Specific Satiety Tests

Sweet-almond water

Ingredients: 1 liter tap water
30 grams Nutrasweet Spoonful
0.4 ml almond extract

Method: Combine all ingredients, and shake well to dissolve.

Sweet-lemon water

Ingredients: 1 liter tap water
30 grams Nutrasweet Spoonful
0.4 ml lemon extract

Method: Combine all ingredients, and shake well to dissolve.

Appendix E: Sensory Specific Satiety Rating Forms

[SSS]
Subject #: _____
Date: _____
Sample #: _____

Instructions: When you are instructed to do so, taste this sample and complete the ratings below. When you have finished, turn to the next page of this ratings and wait until you are instructed to taste the next sample.

How SWEET is this taste?

Not at all _____ Extremely

How FLAVORFUL is this taste?

Not at all _____ Extremely

How much do you like this taste?

Not at all _____ Extremely

JNIFORMED SERVICES UNIVERSITY OF THE HEALTH SCIENCES
F. EDWARD HEBERT SCHOOL OF MEDICINE
4301 JONES BRIDGE ROAD
BETHESDA, MARYLAND 20814-4799

Consent for Participation in a Research Study -Form S

Title of Project: Understanding Eating Behavior
Principal Investigator: Tracy Sbrocco, Ph.D.

Name of Volunteer:_____

TO PERSONS WHO AGREE TO PARTICIPATE IN THIS STUDY:

The following information is provided to inform you about the research project and your participation in it. Please read this form carefully. Please feel free to ask any questions you may have about this study and/or about the information given below.

It is important that you understand that your participation in this study is totally voluntary. You may refuse to participate or choose to withdraw from this study at any time.

If, during the course of the study you should have any questions about the study, your participation ing it or about your rights as a research subject, you may contact:

Tracy Sbrocco, Ph.D., at 301-295-9674
Department of Medical & Clinical Psychology, USUHS, Bethesda, MD 29814-4799

1. INDICATED BELOW ARE THE FOLLOWING:
a. THE PURPOSE OF THIS STUDY
b. THE PROCEDURES TO BE FOLLOWED
c. THE APPROXIMATE DURATION OF THE STUDY

a. THE PURPOSE OF THIS STUDY

Being overweight is a problem for millions of Americans. Overweight is a known risk factor for diseases such as hypertension, diabetes and heart disease. Losing weight has been shown to improve people's health and reduce their risk of disease. However, it is often difficult for people to lose weight and keep it off. Research studies show that in certain situations and with the experience of certain emotions people stop following a weight loss program. The first purpose of this study is to compare overweight people's eating habits to nonoverweight people's habits and to see if these patterns differ and how they relate to energy output. The second purpose of this study is to see if and how taste differs between overweight and nonoverweight people. The third purpose of this study is to compare four weight management programs. Group one will be asked to participate in moderate calorie restriction while avoiding fat-substitutes (for example, low fat cheese). Group two will also have moderate calorie restriction with fat substitutes. The other two groups will be asked to participate in a mild restriction plan, with or without fat substitutes. Eating behavior and attitudes, taste, body weight and body changes will be compared. All groups will receive weekly instruction on principles of weight management that emphasizes education and lifestyle change. Participants do not get to choose which group to participate in. Participation is decided by a process called randomization. Randomization is a method for making assignments by a chance procedure much like flipping a coin.

b. THE PROCEDURES TO BE FOLLOWED:

Individuals meeting a certain weight range and meeting other criteria will be asked to participate in a weight management study. The study will consist of three phases. During the first phase, we will be collecting information on your health, feelings, and eating habits. This phase will take approximately two weeks to complete and people completing this phase, with their physician's permission, will be asked to participate in the second phase. The second phase involves a 12-week weight management program. The third phase is a follow-up period with assessments at 3, 6, and 12 months. The procedures to be followed in each of the three phases are outlined below:

Phase 1 - Initial information collection

At this first visit, we will be asking you to fill out some questionnaires that wiil provide us information on your lifestyle, background, and medical history. You must obtain permission from your primary care physician to participate in the program. We will ask you to sign a release of information so we may inform your physician about the program and communicate with your physician regarding your physical status. We will send a copy of the medical screen you complete today, a program overview, and a physician permission form to your physician. You may not participate without your physician's permission. We will also ask you to complete 2 taste tests and rate how tasty 2 types of pudding are and rate the sweetness of a liquid. Next you will be instructed on keeping an eating diary. We will ask you to keep this diary for two weeks. To qualify for participation in this study, you must return in two weeks with a completed diary. At this return visit, you will be asked to complete questionnaires that give us information about your eating habits and attitudes toward eating and how you feel about yourself in general. In addition, at the first visit we will ask you to schedule two other appointments described below:

Appointment 1. The first appointment will involve an interview with one of the project staff to assess your eating behavior. This interview will take approximately 1/2 hours. You will be interviewed by the principal investigator or a graduate student in psychology. You will be asked questions about your eating behavior. You will be asked to complete several questionnaires that ask you questions about your psychological functioning and your eating behavior.

Appointment 2. Another appointment will be scheduled to measure your body composition. We are interested in estimating how much body fat you have. To do this, you will be asked to remove your shoe and sock/stockings. An electrode will be attached to your foot and your hand while you are laying down. A quick measurement is taken that is painless. This appointment will take approximately 10 minutes.

When you have completed these appointments, turned in a complete diary, and obtained your physician's permission, you will be offered participation in one of the weight loss groups.

Summary for Phase I:

Visit 1 - Group Orientation (1 1/2 - 2 hours)
1. **Complete questionnaires**
2. **Begin 2 week diary**
3. **Complete taste tests**
4. **Schedule 2 appointments**

Visit 2 - Appointment 1 - Complete Interview (1/2 hour)
Visit 3 - Appointment 2 - Body Composition Assessment (10 minutes)
Visit 4 - Second Group Orientation (1 hour)
1. **Return diaries**
2. **Complete questionnaires**

Phase 2 - Weight Management

You will be asked to follow either a moderate restriction (1200 calories a day for women/1600 for men) plan or a mild restriction plan (approximately 2000 calories a day for women/2400 for men). Half of the participants will be asked to avoid fat substitutes such as low fat cheese and fat reduced ice cream. Groups will be made up of approximately 10- 15 people and will be co-led by the principal investigator and a project assistant. Group meetings will last 90 minutes and will be used to teach you new information about weight management, to give you personalized feedback on your eating habits, and help you make permanent changes. Exercise in the form of walking will also be reviewed and encouraged. The group will teach you to eat a low **f**at diet and each week will cover topics on weight management. You will be asked to keep an eating diary throughout most of the program. You will be asked to complete several pen and paper measures each week and you will be weighed weekly.

During the entire 12-week weight loss program, you will be asked to keep a diary to record all meals and snacks. We will use this diary to evaluate the results of the experiment, to give you feedback on your eating habits, and to help determine what changes you need to make to obtain a healthy weight. Measures of your body composition will be used similarly to evaluate the study, to provide individual feedback and to develop individual goals.

Phase 3 - Follow-up

Immediately after finishing the 12-week weight loss program you will be asked to complete the same assessments you completed at the beginning of the study including questionnaires, body composition and the individual interview. You will receive $25 for completing all measures. At the end of 3, 6, and 12 months after treatment you will be asked to attend a group meeting to see how things are going. You will also be asked to complete the same assessment measures: questionnaires, and body composition and, at each follow up assessment (3, 6 & 12 months after treatment). You will receive $25 for completing all measures at each of the follow ups.

c. DURATION OF THE STUDY

The study will last approximately 16 months with 3 1/2 - 4 months of intensive participation. Phase I will last approximately 3 weeks. Phase II will last 3 months. Phase III will last 1 year.

d. SUMMARY OF THE STUDY

	Phase I - Baseline	Phase II-Treatment	Phase III-Follow Up 3mos 6mos 12mos
Time Required	**2-3 weeks**	**12 weeks**	**9 months**
Number of Visits	**4 visits**	**13 visits**	**3 visits**
Payment for Assessments	**None**	**$25 at post-treatment**	**$25 at 3 mos $25 at 6 mos $25 at 12 mos**

2. THIS STUDY IS BEING DONE SOLELY FOR THE PURPOSE OF RESEARCH.

3. DISCOMFORTS, INCONVENIENCES AND/OR RISKS THAT CAN BE REASONABLY EXPECTED ARE:

a. There are no appreciable risks associated with this study. You may find the interviews and the questionnaires cause some mild discomfort. You will be asked to rate the tastes of some foods. You may not like the tastes of some foods. You will not be forced to do anything you do not want to do and you may decline to participate at any time.

b. The study involves a time committment that you may find inconvenient. You will be asked to meet weekly for three months, keep an eating diary, begin a walking program, and to come to the university for several appointments.

c. You will be asked to arrive for some morning visits after fasting overnight (no food after 8:00 p.m.). Some people might find fasting uncomfortable or inconvenient.

4. POSSIBLE BENEFITS TO YOU THAT MAY BE REASONABLY EXPECTED ARE:

You may participate in 12-week weight management program that may help you gain a better understanding of your eating behavior of and body composition and may help you manage your weight. The program and testing are conducted at no charge. You will be paid $25 for completing the post treatment assessment and each of the followup assessments (at 3, 6, and 12 months.)

5. THE BENEFITS TO SCIENCE AND TO HUMANKIND THAT ARE SOUGHT IN THIS STUDY ARE: You will be providing information that will be helpful in expanding scientific knowledge about eating behavior. The results of this study will help us gain a better understanding of how eating patterns of overweight persons compare to normal weight persons and will help us compare two different types of weight management programs to gain a better understanding of what factors are associated with overeating and successful weight maintenance.

6. ALTERNATE PROCEDURES THAT MAY BE ADVANTAGEOUS:
There are many commercial programs available for weight loss. The behavioral program offered is similar in many ways to commercial programs but most likely involves more sophisticated and comprehensive assessment techniques and is offered at no cost.

7. CONFIDENTIALITY: YOUR RIGHTS, WELFARE, AND PRIVACY WILL BE PROTECTED IN THE FOLLOWING MANNER:
Only properly authorized persons such as those directly concerned with the study such as the principal investigator and her assistants, Regulatory Authorities and persons on the Institutional Review Board will be allowed access to your records. Any personal information will be treated as strictly confidential in accordance with applicable laws and regulations, and will not be made publicly available. By signing the consent form attached, you are authorizing such access to your records. All information collected during the study will be anonymous. If information is published, your identity will not be revealed, you will be referred to only by number. (3) Personal information may be revealed during the group sessions. All group members will be informed that group members' names and personal information discussed in group is confidential and should not be discussed outside of the group.

Note: YOU ARE FREE TO WITHDRAW THIS CONSENT AND TO STOP PARTICIPATION IN THIS STUDY OR ANY ACTIVITY AT ANY TIME FOR ANY REASON.

PARTICIPATION IN THIS STUDY OR ANY ACTIVITY AT ANY TIME FOR ANY REASON.

RECOURSE IN THE EVENT OF INJURY

The Department of Defense will provide medical care for DoD eligible members (active duty, dependents, and retired military) for physical injury or illness resulting from participation in this research. Such care may not be available to other research participants, except in the event of an emergency. Compensation may be available through judicial avenues to non-active duty research participants if they are injured.

If at any time you believe you have suffered an injury or illness as a result of participating in this research project, you should contact the Office of Research at the Uniformed Services University of the Health Sciences, Bethesda, Maryland 20814-4799 at (301) 295-3303. This office can review the matter with you, can provide information about your rights as a subject, and

may be able to identify resources available to you. Information about judicial avenues of compensation is available from the University's General Counsel at (301) 295-3028.

Should you have any questions at any time about the study or about your rights you may also contact the principal investigator, Tracy Sbrocco, Ph.D., at the Department of Medical and Clinical Psychology, Uniformed Services University, at (301) 295-9674.

STATEMENT BY PERSON AGREEING TO PARTICIPATE IN THIS RESEARCH PROJECT

I have read this consent form and I understand the procedures to be used in this study and the possible risks, inconveniences, and/or discomforts that may be involved. All of my questions have been answered. I freely and voluntarily choose to participate. In understand I may withdraw at any time. My signature indicates that I have received a copy of this consent form for my information.

SIGNATURES:

_____	_____
Signature of Witness	**Signature of Volunteer**
_____	_____
Witness Name	**Volunteer Name**
Date _____	**Date** _____

I certify that the research study has been explained to the above individual, by me or my research staff, and that the individual understands the nature and purpose, the possible risks and benefits associated with taking part in this research study. Any questions that have been raised, have been answered

Investigator's or
Designee's Signature _____

Printed Name_____

Appendix G: Psion Instruction Sheet.

Psion Psion Psion Psion Psion Psion Psion

1. What is a Psion?

The Psion is a small computer that we are using as a food diary. It can be used for many other things including a word processor and to play games. We won't focus on these other functions.

2. How do I use the Psion as a food diary?

We are going to focus on two functions you will need to use for each meal:

CompDiet is a nutitional database. You enter all foods and beverages for each meal into CompDiet.

Weight asks you to provide other types of information about the meal including where you are and if you were upset before eating.

General Instructions for when and what to enter:
Use the CompDiet program to record all foods and beverages you consume at each meal or snack. A separate entry should be used for each episode of eating or drinking. It is important that you be as complete and exact as possible. Use the Weight program as well to describe the eating situation. We are interested not only in the foods you consume but in the circumstances surrounding your eating. The following line by line instructions will help you in completing the diary. Each program is described in great detail below.

If YOU want to exit the WEIGHT function highlight the last option, Hit **Esc key** to exit, and press the **Esc key** in the upper left corner.

How to keep your eating diary with CompDiet

1. Turn on the Psion by pressing the **Esc key** located on the top left comer of the keyboard.

2. Press an arrow key<—> located at the bottom right of the keyboard until you see CompDiet highlighted, press the Enter key.

3. On the screen you will see COMCARD COMPUTE-A-DIET, press the Menu key located on the bottom left of the keyboard.

4. You wiIl see a menu bar that includes pop down menus for the following: View, Add, Change, Analyse, and Misc. Press an arrow key <—>until you get to Add, then press the arrow key to Subject and press **Enter key** when Subject is highlighted.

5. You will see the subject details screen where you need to press tab key in order to enter your name, sex, age, weight (**tab key** to get to pounds), height (**tab key** to get to feet and inches) and activity (**tab key** to get to different activity levels). Press the **Enter key** to accept activity level. *Please do not enter a number for Kcals, the program will compute it for you.*

6. Press **Esc key** when done. It will ask you if you want to save changes, press **Y key** for yes.

7. A warming will appear on the screen, press **Esc key.**

8. You will see the subject details screen again, press **Menu key** to create a Diet log,

Create a Diet Log:

9. Under **Add on** the menu bar, press an arrow key ↓↑ to **Diet log(s)**, when highlighted press **Enter key**. A short cut would be to press ⌴ **key** and the letter **O key** simultaneously to create a new diet log. [The ⌴ **key** plus any letter key pressed at the same time is called a hot key which is a short cut to executing a command in the CompDiet program]

10. Type name of food, pressing the **Enter key** will take you into the food database so you can find the specific type of food you have eaten.

> For example if you ate a roasted chicken breast, you would type in chicken, press the **Enter** key and then press an **arrow key** ↓↑ to locate chicken, breast, meat only, roasted in the food database.

Press **Enter key** to choose the food and the computer will give you an error message asking you to enter a value press **Esc key** to get rid of the error message. Press the hot key: ⌴**key** and **V key** together so you may enter the weight of the food in ounces. Press the **Enter key** once you have typed in the amount

11. Now press the tab key to enter another food into your diet log. Repeat the steps above to enter the rest of your meal.

12. When you are done, press Menu key and then press an **arrow key** ⟷ until you get to **Misc** on the menu bar. press the **arrow key** ↓ until **Exit** is highlighted, then press the **Enter key**. The hot key to exit the program is ⌴ **key** and **X key**.

13. The program may ask you if you want to save changes, press **Y key** for yes.

14. Create a new diet log after each meal by using the above directions. It is important for you to enter the foods that you have eaten into a diet log soon after you have completed a meal. The log entries are held in date, time and alphabetical sequence.

Changing a Diet Log Entry:

15. You may go back and check your diet logs to ensure you have properly entered all of the food you have eaten on any given day. The hot key to view the diet log entries is ⌴ key and **L key.** Once you have the diet log entries displayed you may press ⌴ and ↓ **key** simultaneously to page down through the diet log quickly.

16. If you realize you have made a mistake entering in a food item, you may change the diet log so it accurately reflects what you have eaten.

First, be sure you have displayed the diet log entries according to the directions above.

** Remember, the hot key is ⌴ L **

Then you need to page down untiI you see the food item(s) you want to change.

Press **Menu key** and an ← → **key** over to **Change**, under it you will see **Amend current item**, press an ↑↓ **key** until it is highlighted and then press the **Enter key.** ** The hot key is ⌴ E **

Now use the **Tab key** or the ↓ **key** until the blinking cursor is on the item you need to change.

17. If the food item is wrong, then type in the correct food and press the **Enter key**.

Now, the food database will appear on your screen, press the ↓ **key** until you see the food you want to select, press the **Enter key** when the food is highlighted.

You will see a message asking if you want to save changes, press the **Y key** if you want the new food item to be in your diet log.

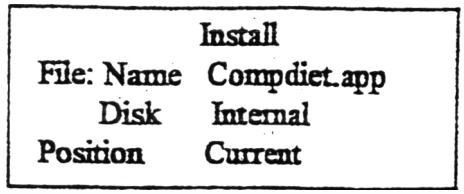
You should check to make sure that the weight of the food item you just added to your diet log is an accurate reflection of what you ate. The above steps only change the food item while leaving the weight of the incorrect food item.

18. To change the weight of a food you must amend the item as in the directions above by first viewing the diet log entries **[** ⌴ L **]** and then changing the entries [⌴ E]. Next, you need to move the cursor so it is blinking on the weight of the item that needs to be changed. Press ⌴ V to allow you to enter the correct weight of the food in ounces. After you have typed m the number, press the **Enter key.**

19. Press the **Enter key** when you are finished changing any items on a page of the diet log. A message will appear is you want to save changes press the **Y key** to save

Troubleshooting:

20. When you are working on the psion it may "freeze" up and not allow you to work in the diet software, the pull down menus will not work and you will be unable to enter food into a diet log. If this happens try to exit the CompDiet by pressing the **Menu key** then → **key** over to **Misc** and ↓ key down until **Exit** is highlighted, press the **Enter key**. This should allow you to exit the CompDiet software and bring you back to the main menu that shows all of the other software programs available on the computer. If you are not able to exit CompDiet or get it to run properly, straighten out a paper clip and gently put one end into the little hole in the top left side ofthe keyboard (just above the **Esc key**). The screen will go blank and after a minute the **Esc key**. You will hear some tones and then you will see a screen with the Psion logo, after 10 - 15 seconds the program icons will appear, but Comp Diet will not be there. Do not panic! Press the **Menu key** and → **key** over to **Apps,** when **Install** is highlighted press the **Enter key**. You will see a little message that says:



21. Do not chang anything on this screen, just press the Enter key and you will see the CompDiet icon reappear!! Now you are ready to use the CompDiet program again and your diet logs should still contain all of the foods you previously entered. If CompDiet froze while you were adding a meal then you should view the diet logs to make sure the log is complete.

Diet Log Entry Problems:

If you are having a hard time finding a particular food item in the food database try the following steps:

22. While in the diet log entry portion of the program press **Menu key,** then → key over to View and ↓ **key** down until Food entries by group/nutrient is highlighted, press the **Enter key**. [The hot key as ⏏ G] Now you can specify food group of the food item you are trying to add to your diet log Press the **Tab key** and a small menu will pop-up on the right side of the screen, now ↓ **key down** until the appropriate food group is highlighted, and press the **Enter key.** You should see the food group category you have chosen an the screen. If you chose the Fast Food category the screen would look something like this:

FOOD/NUTRIENT SELECTION
Press tab for option menus.

Food grp:	(*Fast Food*)	(not set)
Nutrients-		
non-zero	(not set)	(not set)
zero	(not set)	(not set)

23. Now press the **Enter key** to select the food category. You will see an alphabetical list of all the foods in the specific category.You can ↓ key down until you see the correct food, remember the exact way the food is written so you Can enter it into a diet log. Now, to enter this food item you need to go to **Add Diet** log(s) [hot key is ⏏ **O**] and then type in the name of the food exactly as you saw it in the food entries by group section.

Turn Off the Psion:

24. Press ⏏ **key** and the **1 key** simultaneously to turn the Psion off. If you accidently leave the psion on, it will automatically turn off after 5 minutes, but please try and remember to turn it off to save the life of the battery.

Hot Key List:

⌥ O	**Create a diet log**
⌥ V	**Enter weight of food in ounces**
⌥ X	**Exit CompDiet program**
⌥ L	**View previously entered diet logs**
⌥ E	**Ammend current item of diet log**
⌥ G	**View food in database by group**

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